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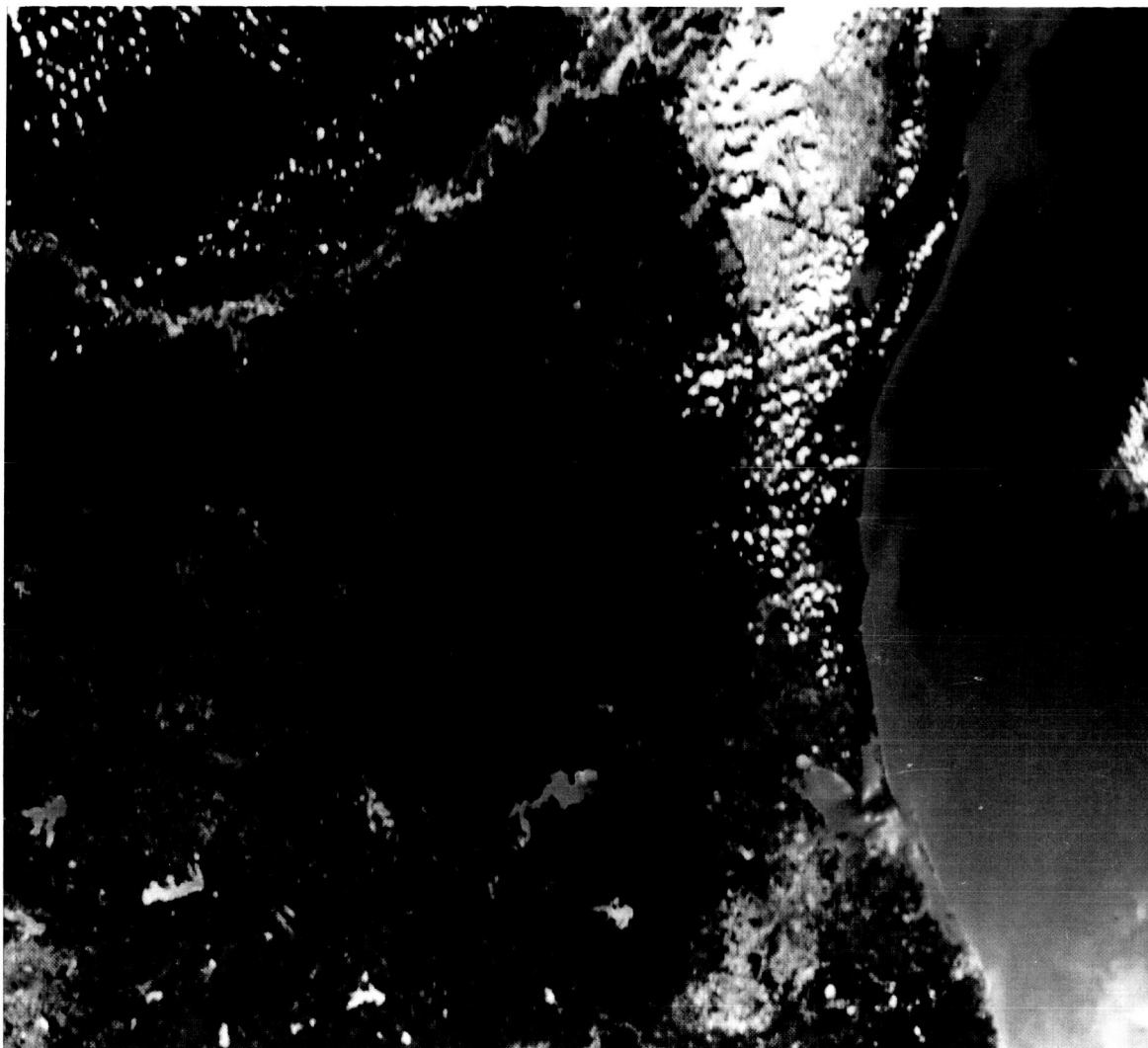
FY 1983

AgRISTARS RESEARCH REPORT

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A Joint Program for Agriculture and Resources
Inventory Surveys Through Aerospace Remote Sensing



COVER

This is a scene over southeastern Texas and southwestern Louisiana acquired by the advanced very high resolution radiometer (AVHRR) on board NOAA-7, which is one of the family of Polar Orbiting Environmental Satellites, on April 18, 1983. This image is composed of the first two of the five channels available on the NOAA-7 AVHRR. Channel 1 covers the green-red portion of the visible spectrum, and channel 2 covers the near-infrared portion of the spectrum. Channel 2 is displayed as red, and channel 1 is displayed as green and blue. The other three channels available on the AVHRR (not displayed in this image) are in the thermal portion of the spectrum. Areas which are deep red and magenta in color are oak-hickory-pine forests; red and pink colors are native vegetation and agricultural areas. Clouds and water appear in their natural colors. The varying tones of blue in the inland lakes and western portion of the Gulf of Mexico are due to sun glint, while the varying shades of blue in the eastern Gulf are due to turbidity. The Dallas-Fort Worth metropolitan area (blue-green in color) can be seen in the extreme top left portion of this image; the Houston metropolitan area is visible in the bottom left (northwest of Galveston Bay). Marsh Island and the Atchafalaya Bay area can be seen in the bottom right. On the right side of the image is the Red River Basin with its meandering tributaries and agricultural areas.

AVHRR data have provided an efficient and inexpensive source of data for agricultural monitoring, condition assessment, and change detection to augment existing satellite, aircraft, and ground technologies.

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AgRISTARS

AGRICULTURE AND RESOURCES INVENTORY SURVEYS THROUGH AEROSPACE

REMOTE SENSING

RESEARCH REPORT - FISCAL YEAR 1983

Prepared by

AgRISTARS Program Management Group

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058

June 1984

PREFACE

The AgRISTARS program was initiated in fiscal year 1980 in response to an initiative issued by the U.S. Department of Agriculture. Led by the USDA, the program is a cooperative effort with the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration of the U.S. Department of Commerce, the U.S. Department of the Interior, and the Agency for International Development of the U.S. Department of State.

The program goal is to determine the usefulness, cost, and extent to which aerospace remote sensing data can be integrated into existing or future USDA systems to improve the objectivity, reliability, timeliness, and adequacy of information required to carry out USDA missions.

The program is well underway, with encouraging progress having been made in fiscal years 1980,* 1981,[†] 1982,[§] and 1983 (as documented in this report). The outlook is that aerospace remote sensing will contribute to USDA information needs in a significant way and, more generally, that the AgRISTARS effort will advance this technology for use in other areas of national need.

* AgRISTARS Annual Report - Fiscal Year 1980; AP-J0-04111, National Aeronautics and Space Administration (NASA), Lyndon B. Johnson Space Center (JSC), June 1981.

[†] AgRISTARS Annual Report - Fiscal Year 1981; AP-J2-04225, NASA/JSC, January 1982.

[§] AgRISTARS Research Report - Fiscal Year 1982; AP-J2-0393, NASA/JSC, January 1983.

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ACRONYMS AND ABBREVIATIONS

ACCS	Ambroziak Color Coordinate System
AgRISTARS	Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing
agromet	agricultural-meteorological
AID	Agency for International Development
AMMR	airborne multichannel microwave radiometer
APU	agrophysical unit
ARS	Agricultural Research Service
AVI	Ashburn vegetative index
AVHRR	advanced very high resolution radiometer
CAM	correlation area method
CCT	computer-compatible tape
CEAS	Center for Environmental Assessment Services
CERES	Crop Estimation through Resource Environment Synthesis
CMI	crop moisture index
C/P	Conservation and Pollution
CPU	computer processing unit
CRD	crop reporting district
CWSI	crop water stress index
DC/LC	Domestic Crops and Land Cover
DCM	digital count minimum values
EDIS	Environmental Data and Information Service
ET	evapotranspiration
EVI	environmental vegetation index
EW/CCA	Early Warning and Crop Condition Assessment
FAS	Foreign Agricultural Service
FY	fiscal year
GIS	geographic information system
GLAI	green leaf area index
GMI	Gray/McCrary index
GOES	Geostationary Operational Environmental Satellite
GSFC	Goddard Space Flight Center

HIRS/2	high resolution infrared radiation sounder 2
ICC	Interagency Coordinating Committee
IFOV	instantaneous field of view
IPAR	intercepted photosynthetically active radiation
ITD	Inventory Technology Development
JES	June Enumerative Survey
JPL	Jet Propulsion Laboratory
JSC	Lyndon B. Johnson Space Center
LAI	leaf area index
MIMPT	Multiresource Inventory Methods Pilot Test
MSS	multispectral scanner
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite, Data, and Information Service
NESS	National Environmental Satellite Service
NMR	nuclear magnetic resonance
NOAA	National Oceanic and Atmospheric Administration
NRI	National Resource Inventory
NWS	National Weather Service
NWSRFS	National Weather Service River Forecast System
pixel	picture element
PMG	Program Management Group
ppm	parts per million
RMSE	root mean square error
RRI	Renewable Resources Inventory
SAM	satellite, agronomic, and meteorological
SAR	synthetic aperture radar
SCS	Soil Conservation Service
SIR-A	Shuttle imaging radar A
SM	Soil Moisture
SMR	scanning multichannel microwave radiometer
S/N	signal-to-noise
SR	Supporting Research
SRM	snowmelt-runoff model
SRS	Statistical Reporting Service

TAMW	Texas A&M wheat model
TIROS	Television Infrared Observation Satellite
TM	thematic mapper
TMS	thematic mapper simulator
TOVS	TIROS operational vertical sounder
USDA	U.S. Department of Agriculture
USDC	U.S. Department of Commerce
USDI	U.S. Department of Interior
USGS	U.S. Geological Survey
USLE	universal soil loss equation
VI	vegetation index
VIN	vegetation index number
WMO	World Meteorological Organization
YMD	Yield Model Development

I. PURPOSE

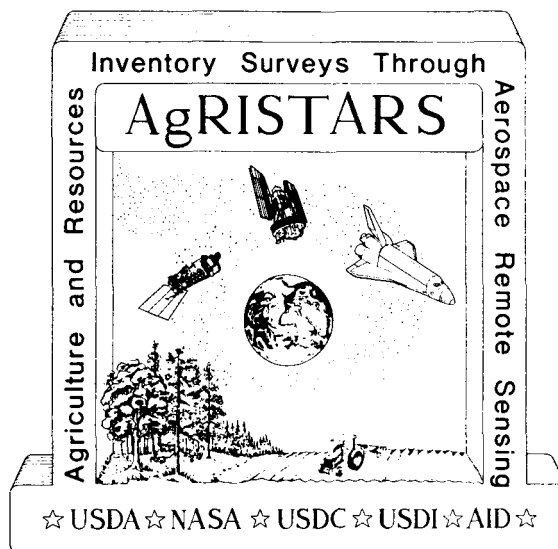
The purpose of this report is to present the major objectives and accomplishments of the Agriculture and Resources Inventory Surveys Through Aerospace Remote Sensing (AgRISTARS) program and its eight component projects during fiscal year (FY) 1983.

This report includes an introduction to the overall AgRISTARS program, a general statement on progress, and separate summaries of the activities of each project, with emphasis on the tech-

nical highlights. Organizational and management information on AgRISTARS is included in the appendixes, as is a complete bibliography of publications and reports. Additional information may be obtained from:

AgRISTARS Program Management Group
Code SC

NASA-Lyndon B. Johnson Space Center
Houston, Texas 77058
Telephone: 713-483-2548
(FTS: 525-2548)



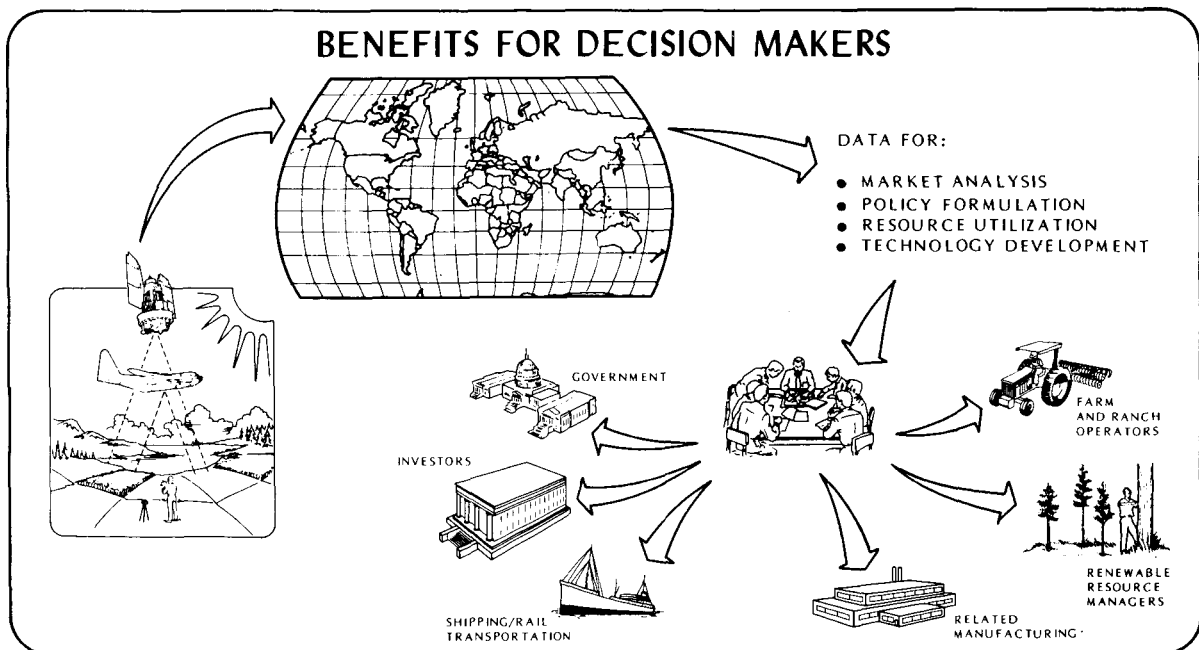
2. INTRODUCTION

AgRISTARS is a long-term program of research, development, test, and evaluation of aerospace remote sensing to meet the needs of the U.S. Department of Agriculture (USDA). The program is a cooperative effort of: the USDA; the National Aeronautics and Space Administration (NASA); the U.S. Department of Commerce (USDC) through the National Oceanic and Atmospheric Administration (NOAA); and the U.S. Department of the Interior (USDI). In addition, the Agency for International Development (AID) participates as an ex officio observer and potential future user agency.

In 1978 the Secretary of Agriculture issued an initiative,¹ in response to

which the participating agencies established the AgRISTARS program. In 1980 the program was initiated as an effort based on satisfying current and future requirements of the USDA for high-priority agricultural and other renewable resources type information. This information is important to the USDA in addressing national and international issues on supply, demand, and competition for food and fiber.

¹Joint Program of Research and Development of Uses of Aerospace Technology for Agricultural Programs, February 1978.



The overall goal of AgRISTARS is to determine the feasibility of integrating aerospace remote sensing technology into existing or future USDA data acquisition systems. Determining feasibility depends upon the assessment of numerous factors over an extended period of time. Determinations of the reliability, costs, timeliness, objectivity, and adequacy of information required to carry out USDA missions are planned in the program. The overall approach consists of a balanced program of remote sensing research, development, and testing which addresses a wide range of information needs on domestic and global resources and agricultural commodities.

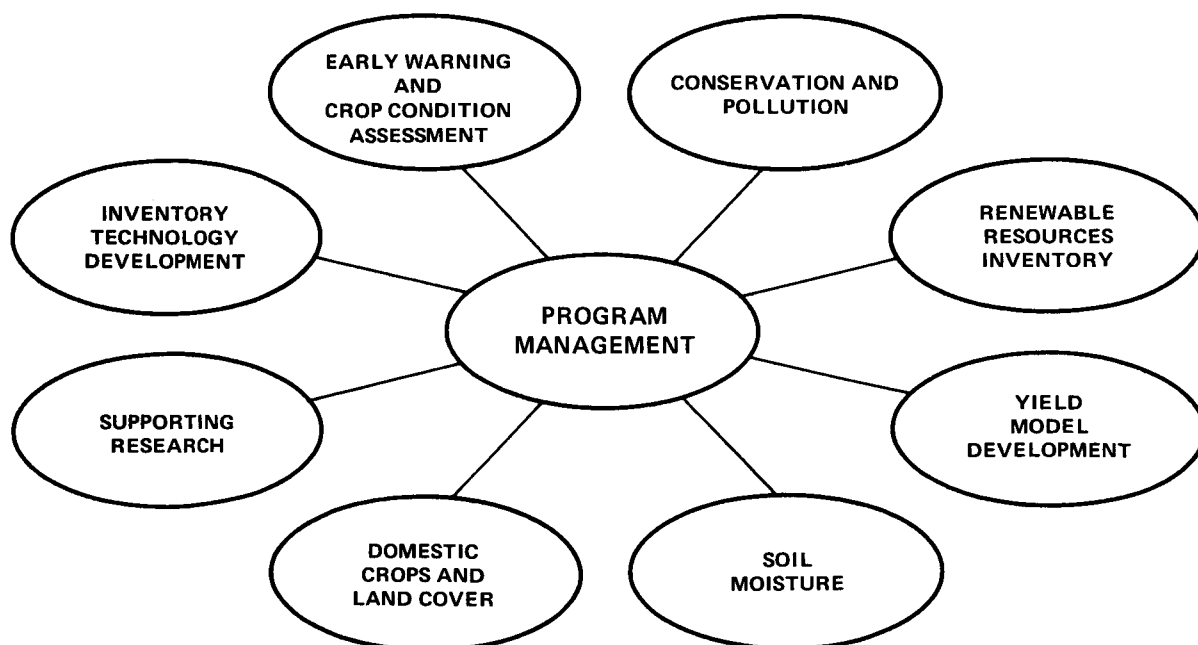
In this initiative the USDA identified the following seven information requirements:

- Early warning of change affecting production and quality of commodities and renewable resources

- Commodity production forecasts
- Land use classification and measurement
- Renewable resources inventory and assessment
- Land productivity estimates
- Conservation practices assessment
- Pollution detection and impact evaluations

Based on these information requirements, as well as on a specific immediate need for better or more timely information on crop conditions and expected production, the AgRISTARS technical program was developed. It consists of eight projects which address all seven of the USDA information needs with a clear emphasis on the first two, early warning

AgRISTARS PROJECTS



of change and commodity production forecasts. The eight projects include the following:

- Early Warning and Crop Condition Assessment (EW/CCA)
- Inventory Technology Development (ITD)
- Supporting Research (SR)
- Yield Model Development (YMD)

- Soil Moisture (SM)
- Domestic Crops and Land Cover (DC/LC)
- Renewable Resources Inventory (RRI)
- Conservation and Pollution (C/P)

Even though each project has its specific set of objectives, the projects are interrelated both through mutuality of data needs and through much common technology.

3. PROGRAM SUMMARY

The AgRISTARS program has been underway for 4 years. During this time significant progress has been made in evaluating, analyzing, and using various types of remote sensing data for agricultural applications.

Research conducted by the AgRISTARS projects has been evaluated by USDA agencies, and selected techniques have been incorporated into the domestic and foreign operational crop production estimation programs. During FY 1983, the AgRISTARS program focused on three areas: technology transfer, basic research, and evaluation of the NOAA satellites.

Technology Transfer

The USDA Statistical Reporting Service (SRS) used acreage estimates generated from Landsat multispectral scanner (MSS) data to support U.S. crop estimates. Acreage estimates for seven states - Arkansas, Colorado, Illinois, Iowa, Kansas, and Missouri - calculated by combining Landsat MSS with ground data, were twice as efficient as estimates using ground data alone; projected costs per state associated with using Landsat data have been drastically reduced, thereby enhancing Landsat's utility to domestic crop production estimation.

- A revised wheat yield reduction model was transferred to the Foreign Agricultural Service (FAS) and tested in both the USSR and China. Model results compared favorably with non-satellite data sources.
- FAS also used the Crop Estimation through Resource Environment Synthesis (CERES) winter wheat model to produce operational yield estimates for the USSR.

- The CERES-maize model was used in real time (1983 crop season) to evaluate the U.S. corn crop and the impact of the drought on corn yield.
- The Soil Conservation Service (SCS) is reviewing Landsat change detection techniques for possible use in the National Resource Inventory (NRI) program.
- The USDA Forest Service placed considerable emphasis on transferring remote sensing techniques to field users by conducting several advanced remote sensing and photo interpretation workshops.
- Results from 14 international basins indicate that the accuracy of the snowmelt-runoff model (SRM) for simulating seasonal water yield (volume) is 97 percent and for daily flows is 85 percent. This model is ready for conversion to operational forecasting.
- Vegetation indices developed in AgRISTARS, using the Landsat MSS or the NOAA advanced very high resolution radiometer (AVHRR), are used operationally by estimating and forecasting groups in USDA, NOAA, and AID.

Principal Technical Accomplishments

- A major technical interchange meeting was held between AgRISTARS participants and other government and non-government researchers on the use of the NOAA satellites AVHRR for agricultural applications.
- Methods to estimate precipitation, daily temperature extremes, canopy temperatures, insolation, and snow

cover from meteorological satellites are in the final phases of testing and evaluation.

- Continued evaluation of thematic mapper (TM) data for crop identification, land cover separability, and forest species discrimination has shown that TM data can discriminate to levels II and III of the U.S. Geological Survey (USGS) land cover categories. The TM's improved accuracy is attributed to better spatial and radiometric resolution, improved wavelength (band) coverage, and better signal-to-noise (S/N) ratio.
- Improved spectral and spatial resolution of TM offers the potential to separate important soil properties even in regions with similar soils and under a dense vegetation canopy.
- A soybean phenology (growth stage) model was developed and tested. The results indicate that the model will generate reliable estimates of soybean growth stages over a wide range of climatic conditions.
- Agroclimatic reference handbooks were prepared for Argentina, Brazil, and Australia.
- Microwave remote sensing of bare soil produced repeatable and quantifiable results regardless of geographic location and sensor system used, thereby demonstrating the potential of microwave remote sensing for estimating soil moisture over large areas.
- The Multiresource Inventory Methods Pilot Test (MIMPT) was completed. The MIMPT demonstrated the potential use of Landsat data for conducting recurrent forest inventory and assessment activities over large areas.

- Preliminary data analysis during FY 1983 indicated that some conservation practices could be successfully detected in Landsat TM data, but a number of existing practices are of such size and definition that present sensors and standard techniques cannot detect them with great accuracy.
- A new hydrologic model has been developed to incorporate remote sensing information from various sensors for water resources management. This model will be field tested in FY 1984.

Major Research Focus During FY 1983

During FY 1983 a major part of the research effort focused on the use of the NOAA polar-orbiting satellites for agricultural monitoring and condition assessment. The NOAA satellites have AVHRR's onboard that collect data in the visible, infrared, and thermal bands. The spectral response of the visible and near-infrared bands is similar to bands 5 and 7 on the Landsat MSS. The AVHRR continuously scans the globe at a resolution of 1 kilometer. The 1-kilometer data is aggregated automatically to a resolution of 4 kilometers onboard the satellite in order to conform to data storage constraints. About 10 minutes of selected higher resolution 1-kilometer data can be stored onboard during each orbit. The advantage of the NOAA satellites for monitoring vegetation is that they provide daily observations, while Landsat has a repeat time of 16 days. Problems with cloud cover are much less severe with daily observations. The trade-off for daily coverage is resolution. Only a small part of the Earth can be observed daily at the full 1-kilometer AVHRR resolution; daily global coverage is obtained at a 4-kilometer resolution.

During FY 1983, basic research was conducted on improving the processing

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efficiencies of the AVHRR data through cloud screening techniques, geometric rectification, registration, scan angle corrections, and swath width studies (fig. 1). Additional studies investigated the use of the thermal bands for estimation of precipitation, temperature, surface evaporation, and ocean water reflectances.

In the applications area, various daily, global, and composite vegetation indices (VI's) were produced (fig. 2) and used within the assessment groups at USDA, NOAA, and AID.



Figure 1.- NOAA AVHRR image of the Southern United States. This image product is the western half of a full AVHRR scan. It illustrates the effects of scan angle on data distortion. The Winter Wheat belt of Oklahoma and Kansas is the red area in the central portion of the image.

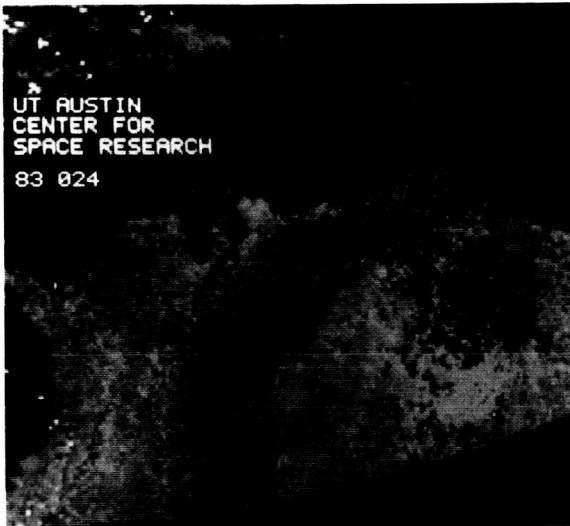
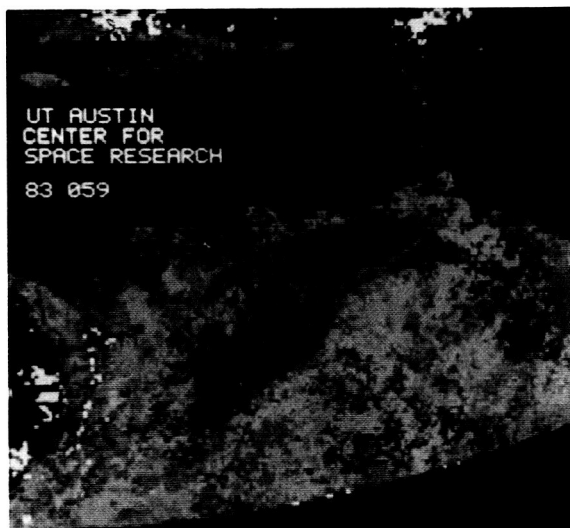


Figure 2.- Progression of severe drought in the Orinoco and Mehta River Basins of Columbia and Venezuela during early 1983. This new operational product of aggregated AVHRR daily data is available weekly and is designed to give analysts a quick-look of the overall environmental trends.



The browns in Columbia and Venezuela document the dessication of the grasslands that was associated with El Nino of 1982-83. Also noticeable is the greenness contrast between the two nations of Haiti and the Dominican Republic on the Island of Hispaniola. The cause of the lower greenness in Haiti (western end of the island) is due to severe deforestation (less than 2% of the country remains as forest) and subsequent erosion.

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The AVHRR was able to track catastrophic or large area events - Mexico's El Chicon volcano eruption, drought in the African Sahel, and reductions in the water level of Lake Chad, and a massive phytoplankton bloom off the northeast coast of Australia (fig. 3).

The NOAA polar-orbiting satellites have provided an efficient, inexpensive source of data for agricultural monitoring, condition assessment, and change detection to augment existing satellite and ground technologies.



Figure 3.- NOAA-8 image of phytoplankton bloom off northeast coast of Australia. This image was taken in December 1983 of a portion of the Great Barrier Reef. The chlorophyll greenness signature being exhibited by this mass of single-celled blue-green algae covered about 30,000 square kilometers of the Capricorn Channel off the coast of Queensland, Australia. The greenness of this phytoplankton bloom equals that measured for soybeans previously. Water depths in this region are generally less than 100 feet over a coralline sandy bottom. The entrapment of this phytoplankton concentration in the Capricorn Channel is probably related to entrainment in a warm-core gyre being spun out of the Coral Sea, a normal occurrence in this region during the Southern Hemisphere summer.

4. PROJECT TECHNICAL HIGHLIGHTS

Technical highlights of the eight AgRISTARS projects are given in this section. Project overview, FY 1983 objectives, and accomplishments are discussed.

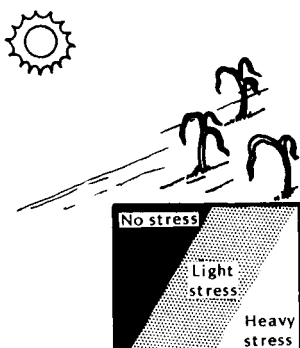
4.1 EARLY WARNING/CROP CONDITION ASSESSMENT

The EW/CCA research project is designed to develop remote sensing technology and crop simulation models that provide early warning of actual or potential plant stress and that provide alerts for optimal crop conditions. The project activity includes development and testing of techniques for monitoring and assessing conditions that may impact crop production in foreign and U.S. areas. Major commodities for which technology is being developed include: small grains (wheat and barley), corn, soybeans, sorghum, sunflowers, and cotton.

EARLY WARNING OF CONDITIONS AFFECTING CROPS

This project will assist the USDA in tracking the condition of major crops in the United States and foreign countries.

Techniques using data from satellites to measure the effects of drought on crops are well developed, and the areas of the crops affected can be accurately measured. Other types of crop stress are also being studied.



Technology developed in the EW/CCA project will be transferred to elements within USDA. For example, the USDA/FAS is responsible for providing early warning of changes that may affect

crop production in foreign countries and for assessing crop conditions in general. They have provided research requirements and have requested that specific technology be transferred to their Foreign Crop Condition Assessment Division.

The EW/CCA project is managed by the USDA Agricultural Research Service (ARS) with participation by NASA, NOAA, and other USDA agencies.

4.1.1 Technical Objectives

The FY 1983 objectives were:

- To continue development and evaluation of various simulation models and satellite data to provide timely alerts of abnormal conditions on a global basis.
- To provide improved definition of the relationships between plants and their environment and factors affecting the growth cycle.
- To determine and quantify relationships between factors such as crop stress, the environment, and spectral responses.
- To investigate the utility of multi-sensor data for agricultural applications and to improve the capabilities for using NOAA satellite data for indicating and monitoring crop conditions.

4.1.2 Crop Stress Indicator Models

Models are being developed, tested, or improved to provide information concerning crop stress.

A satellite, agronomic, and meteorological (SAM) data base for Missouri,

North Dakota, and South Dakota was developed to test and evaluate the accuracy of the wheat, corn, and sorghum stress indicator models. The SAM data base was established using ground-truth information obtained from the USDA/SRS weekly crop weather bulletins, plus data extracted from the EW/CCA geographic data base. The stress models track crop phenology and soil water status and provide stress alerts. Each component is being evaluated for accuracy and for relationships among available soil water, crop phenology, stress alerts, and various vegetative indices computed from satellite data. The crop stage model components appear to be quite accurate for corn (fig. 4).

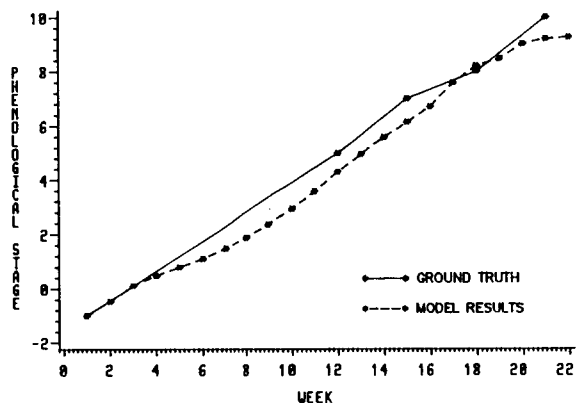


Figure 4.- Comparison of model-estimated corn phenology with ground data.

However, the spring wheat phenology component (Robertson's crop calendar) appears to estimate inaccurately crop phenology after the heading stage (fig. 5). This conclusion is based on limited testing; additional testing is continuing, and modifications will be made to improve the model's accuracy.

Efforts continued toward the development of a meteorologically driven stripe rust indicator model and spectral responses associated with rust-infected

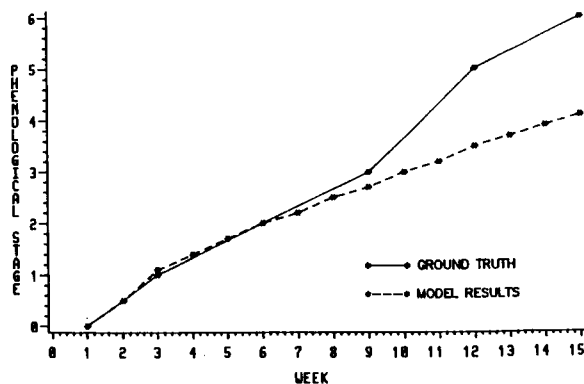


Figure 5.- Comparison of model-estimated wheat phenology with ground data.

wheat and barley. Figure 6 illustrates the influence that rust has on spectrally derived VI values $[(\text{channel } 7 - \text{channel } 5)/(\text{channel } 7 + \text{channel } 5)]$ computed from data collected with a handheld radiometer. Spectral VI's began to decrease soon after wheat plants were inoculated with rust spores. As the

MONTANA RUST DISEASE STUDY EXOTECH RADIOMETER

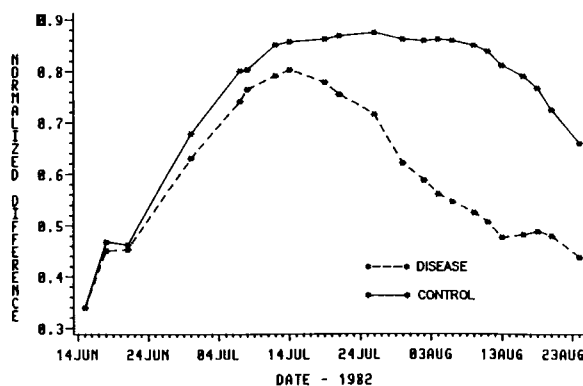


Figure 6.- The effect of leaf rust on remotely sensed vegetation index numbers during the growing season for wheat.

plants matured and the disease level increased, VI values became increasingly smaller than those from nondiseased plants. This provided evidence that crop conditions may be monitored from satellite platforms for the presence of disease if favorable conditions exist for disease outbreaks. The meteorologically driven rust indicator model should provide information suggesting which moisture conditions are favorable for rust epidemics. Since good moisture conditions must exist for rust outbreaks to occur, a decline in VI numbers may be attributed to disease and not to drought.

A conceptual design was developed for a harvest loss wheat model based on 3 years of field and laboratory studies conducted in North Dakota. The model will provide information relative to sprouting, quality, and yield loss. A major problem associated with model development is the inability to determine drying rates following a period of precipitation. Humidity measurements, if available from first order weather stations, would be useful in predicting the dry-down rate.

4.1.3 Condition Assessment

Major modifications were made to a wheat yield reduction model developed in 1982. The revised model was transferred to FAS and tested in both the USSR and China. Figure 7 illustrates the results obtained for three major winter wheat producing provinces in the North China Plain. The model suggests that the potential for yield reductions was greater in 1982 (53 percent) than in 1983 (42 percent). Reports from China verify that better yields were obtained in 1983 than in 1982. Additional testing of this model will be accomplished using the SAM data base and ARS experimental plot data from various research locations in the United States.

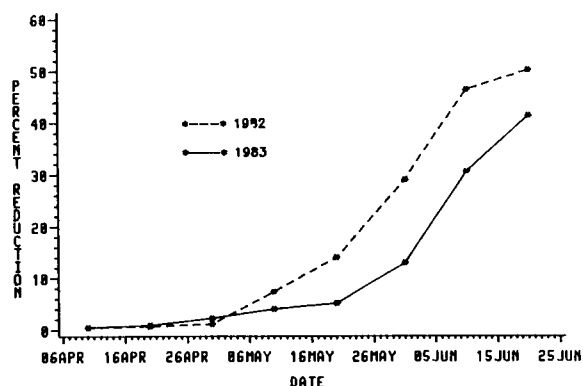


Figure 7.- Estimated 1982 and 1983 wheat yield reduction potentials for major wheat provinces in China.

A crop water stress index (CWSI) was calculated for cotton plants exposed to different early season irrigation treatments. It was responsive to plant water status, attaining minimum values following an irrigation and then increasing gradually as plants depleted soil moisture reserves. The final yield of seed cotton was significantly and inversely correlated with the average midday CWSI observed over a 3-month fruitsetting interval. This information can be used to establish guidelines for using infrared thermometry for scheduling cotton irrigations and for quantifying the magnitude and duration of stress between irrigations in order to achieve the appropriate balance between vegetative and reproductive patterns of growth. Infrared thermometry provides several important advantages over conventional approaches for quantifying stress and monitoring yield potential. It is a rapid, nondestructive technique which can be used to survey large acreages in a cost effective fashion while circumventing many of the sampling problems associated with point measurements.

In 1982 the EW/CCA project reported that Landsat VIN's of native rangelands

could be used to monitor drought stress in adjacent croplands. Continued research in 1983 suggests that VI's computed for all picture elements (pixels) within a segment may provide drought stress information similar to that of native rangelands (fig. 8). The results show that VI's computed for rangeland areas and those for all pixels within the segment followed similar patterns throughout the season and that both trajectory curves respond to increasing or decreasing crop moisture index levels. These findings suggest that NOAA-AVHRR satellite data (1-kilometer resolution) can provide adequate information to monitor crop moisture stress in the U.S. Great Plains or in other semiarid regions of the world.

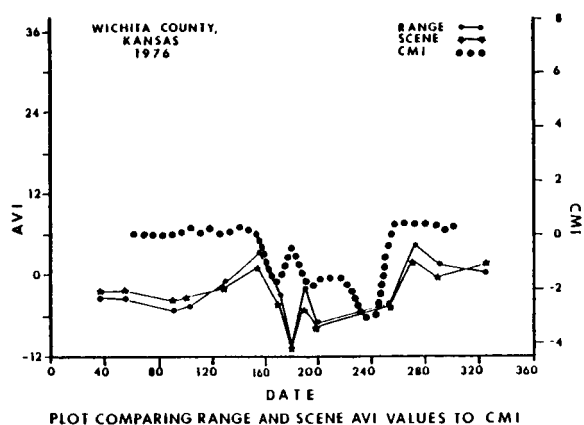


Figure 8.- Seasonal trajectories depicting rangeland and total scene vegetation indices (AVI) and the crop moisture index.

4.1.4 Crop/Spectral Research

Techniques are being developed and tested to incorporate spectral indicators of vegetation development and growing conditions into agrometeorological growth and yield models. For example, interrelations exist between leaf area

index (LAI), intercepted photosynthetically active radiation (IPAR), yield, and spectral VI's derived from remote observations of plant canopies.

Spectrally derived VI's can be used to estimate LAI and IPAR for use in plant growth/yield model algorithms developed from experimental data. Relationships between yield and VI's can provide independent checks for agrometeorological growth and yield model outputs.

The reflectance of solar radiation by the soil background complicates the discrimination of vegetation by remote sensing. To study this effect, dry and wet reflectance data, for 20 soils covering a wide range in spectral properties, were obtained with a handheld radiometer. Principal components analysis was used to study the distribution of soil spectra in four-dimensional space and to define a mean soil line. Analysis of the mean soil line showed that it was not possible to discriminate bare soil from low vegetation densities. Greenness measurements were shown to be sensitive to both soil type and soil moisture condition. In contrast, the use of individual soil lines as a base to measure greenness minimized soil background influence and improved vegetation assessment, particularly in the case of low green plant canopy covers. These results show the importance of using specific soil spectra in vegetation discrimination.

In another study, spectral reflectance at two wavelengths (0.55 and 0.65 millimeters) was investigated using single leaves of fertilized and nonfertilized buffelgrass. Chlorophyll concentration and nitrogen content were less in nonfertilized leaves than in leaves receiving more than 112 kilograms of nitrogen per hectare. Significantly higher reflectance values, at the 0.55-millimeter wavelength, were measured from nonfertilized than from fertilized leaves.

Nonfertilized plots could also be distinguished from fertilized plots using color-infrared aerial photography. These results indicate that leaf reflectance measurements may be useful for estimating protein content and green biomass production of buffelgrass.

Reflectance measurements of Produra wheat fields were made at 13 different times of the day at Phoenix, Arizona, using a handheld radiometer with bandpass characteristics similar to those of the Landsat MSS. The major objective was to determine the effect of changing sun angles on the reflectance properties of canopies in various phenological stages and with different levels of green leaf area index (GLAI). Results indicated that diurnal changes in each of the four Landsat wavebands and several indices derived from them are related to canopy architecture, percentage of cover, and vertical distribution of green leaves within the canopy. Multispectral data acquired under differing sun altitude and azimuth angles contain important information regarding the three-dimensional distribution of plant material which can be extracted to determine phenological stage of growth or to estimate levels of stress. Additional analysis showed that substantial errors could be introduced into the estimate of GLAI from spectral observations if the diurnal patterns of reflectance caused by changing sun angles are not properly incorporated.

When plants are stressed because of insufficient water, both physiological and geometric changes occur, thereby increasing the complexity of the interpretation of spectral data. To study these effects, spectral responses in eight wavebands (three visible, two near-infrared, two mid-infrared, and one thermal-infrared) were measured by repetitively traversing a radiometer over several rows of cotton. After an initial measurement the stems of one row were

cut at a point just above the soil. The subsequent dessication of plants within this row was followed by comparing reflectance and emittance of the row with that of a control row. Measurements in all wavebands reacted rapidly to stress, with the visible and thermal-infrared showing a larger change than the near-infrared. Reflectance changes caused by canopy geometry changes were apparently greater than those caused by leaf physiological and anatomical changes in all but the visible red band. The increase in red reflectance was attributed to a rapid decrease in absorptance by leaf chloroplasts. As expected, the radiometrically determined plant temperatures increased with time after the stress was imposed. These results demonstrate that canopy geometry changes caused by stress must be accounted for if plant water stress is to be quantified using reflectance measurements.

4.1.4 Aircraft and Satellite Investigations

Aircraft

Three black-and-white video cameras, each fitted with different narrowband filters, were used together in an aircraft to obtain information about agricultural crop and soil conditions. Inflight information was recorded on video equipment, and upon landing, the video tapes were ready for television (TV) displays and computer image analysis. Variations in reflective characteristics of landscape features were clearly evident between wavebands. False color composites, made using the computer image analysis system, were similar in appearance to color infrared photographs. These results suggest that a modified color video camera system and appropriate narrowband filters can enhance the information needs of agricultural managers in near real time. The TV formatted outputs of video systems make them a natural for transmission of

images over electronic agricultural information networks of the future.

Combined Sensors

Linear combinations of spectral bands form physically significant VI's. Indices comprised of two and four bands have been used to discriminate vegetation from soil background. A procedure for calculating vegetation indices using any number of bands was evaluated. Reflectance values were obtained for each band for each sensor. VI's were calculated for various band combinations for the several sensors, and their dynamic ranges for a 0- to 100-percent change in vegetation were compared. A six-band VI calculated using six of the TM bands had the greatest dynamic range, followed closely by two five-band and one four-band index from the same sensor. The two-band index using bands 4 (near-infrared) and 7 (mid-infrared) of the TM had a greater dynamic range than any band combination of the other four satellite sensors. The four-band index of the Landsat-4 MSS and the three-band index of the French satellite SPOT were similar. The two-band indices from the AVHRR sensors on NOAA-6 and NOAA-7 changed less with vegetation changes than did the other three. This development means an improved ability to discriminate and evaluate vegetation from remote platforms.

NOAA Satellites

During the past year extensive work has been initiated on the use of the NOAA satellites for agricultural monitoring. Two locations have been principal contributors to this research.

Camp Springs, Maryland

Part of the AgRISTARS effort under way at the NOAA National Environmental Satellite, Data, and Information

Service (NESDIS) is to develop products from operational meteorological satellite data that will supplement ground-based weather observations for agricultural monitoring. Meteorological quantities that are needed for crop models and that can be produced from satellite data include estimates of precipitation, daily temperature extremes, canopy temperatures, insolation, snowcover, and VI's.

The NOAA polar-orbiting satellites have AVHRR's onboard that make observations in the visible band (channel 1, 0.58 to 0.90 millimeters) and in the near-infrared band (channel 2, 0.73 to 1.10 millimeters). The spectral responses for these bands are similar to responses for bands 5 and 7 on the Landsat MSS.

The reflectance of green vegetation in the visible part of the spectrum is low (20 percent or less) but is much higher (50 to 60 percent) in the near-infrared. Other surfaces, such as water, bare ground, and clouds have reflectances that are nearly the same in the two bands. Thus, the difference between measurements in channels 1 and 2 is a sensitive indicator of vegetation. The differential reflectance of vegetation in the visible or near-infrared was used with MSS data to estimate crop acreage, to study the distribution and condition of vegetation, and to detect plant stress. The advantage of the NOAA satellites for monitoring vegetation is that they provide daily observations while Landsat has a repeat time of 16 days. Cloud obscuration of the areas of interest is much less of a problem with daily observations. The trade-off for daily coverage is resolution. Only a small part of the Earth can be observed daily at the full 1-kilometer AVHRR resolution; daily global coverage is obtained at 4-kilometer resolution.

Examples of an experimental VI product are shown in figures 9 and 10.

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Figure 9.- Northern Hemisphere composite AVHRR image of the normalized difference vegetation index $[(\text{channel } 2 - \text{channel } 1)/(\text{channel } 2 + \text{channel } 1)]$ for August 23-29, 1982.

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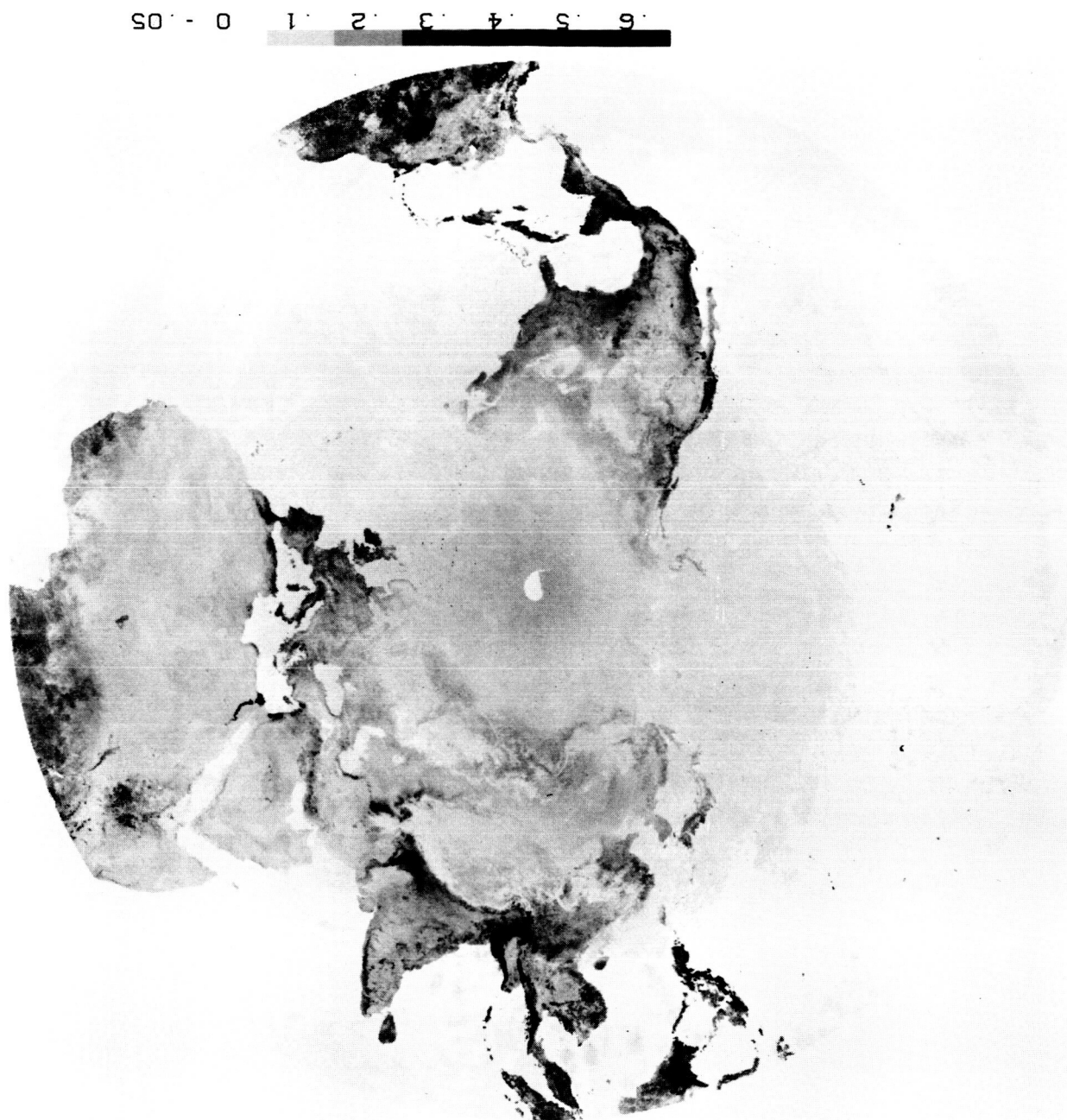


Figure 10.- Northern Hemisphere composite AVHRR image of the normalized difference vegetation index $[(\text{channel } 2 - \text{channel } 1) / (\text{channel } 2 + \text{channel } 1)]$ for March 21-27, 1983.

These are Northern Hemisphere, polar-stereographic mapped images of the normalized difference $[(\text{channel } 2 - \text{channel } 1)/(\text{channel } 2 + \text{channel } 1)]$ vegetation index. The greener the scene, the darker the image and the higher the VI value, which ranges between 0.1 and 0.6 for most vegetation. The images were generated from 4-kilometer AVHRR observations made during the week of August 23-29, 1982, and March 21-27, 1983. The data were mapped each day into a 1024- x 1024-pixel polar stereographic array and composited over a 7-day period by saving the greenest observation for each array point. Atmospheric effects, such as Rayleigh and Mie scattering and subpixel clouds, reduce the radiance in channel 2 relative to channel 1 and reduce the value of the data. Saving the greenest observation over the 7-day period minimizes cloud and atmospheric effects and throws out high nadir-angle observations in favor of straight-down looks. The disadvantage of saving the greenest observation is that it can bias the sampling toward the greener vegetation (forest, irrigated land, etc.). The usefulness of this product for monitoring global agriculture is being evaluated by units of NOAA and USDA.

Insolation, the primary energy source for growing crops, is used in numerical models for estimating crop yield, potential evaporation, and soil moisture. The amount of solar radiation reaching the surface is determined by the transmittance. Under overcast conditions, up to 60 to 70 percent of incident solar radiation may be reflected to space and another 10 to 15 percent absorbed within the cloud. The satellite directly observes the reflected component of the incident radiation, so satellite measurements in the visible part of the spectrum are directly related to insolation at the surface. The NOAA Geostationary Operational Environmental Satellite (GOES) is the preferred data source for

satellite estimates of insolation because its repeated observations throughout a day allow tracking of changing cloud conditions. Where geostationary data are not available, techniques using polar orbiter data have been developed.

An insolation method has been developed that uses hourly GOES visible data to estimate hourly insolation. The technique involves regression against observed target brightness as measured by GOES, and the known brightness of the target under clear conditions. The difference between these two quantities is a measure of cloudiness. Hourly estimates are summed to give a daily total insolation, which is the measure used in agricultural models. Figure 11 shows a comparison of satellite estimates of daily insolation against pyranometers. These data are for satellite estimates collocated with selected sites in the NOAA pyranometer network. Insolation estimates are currently being made and archived for all of the United States and for agriculturally important areas in Mexico and South America.

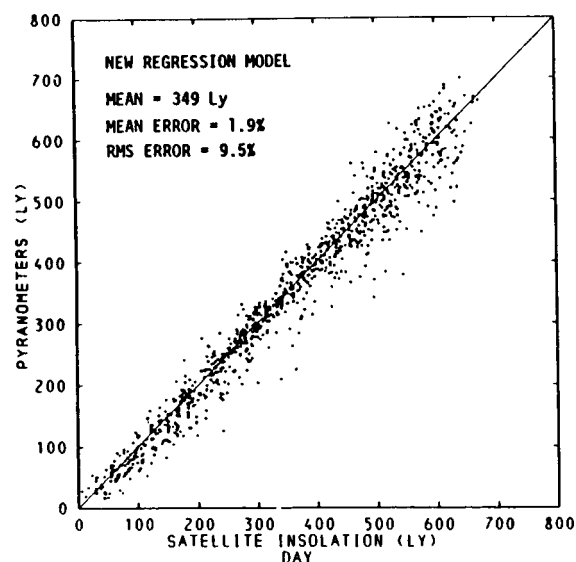


Figure 11.- Observed daily total insolation versus satellite estimates using hourly GOES data.

Canopy temperature, shelter temperature, dewpoint temperature, and daily maximum and minimum temperatures are all needed for use in crop and soil moisture models. Surface temperature has a high spatial variability which contributes to crop forecasting errors where observations are sparse and not representative of the whole region. Quantities derived from satellite data are area averages. For large agricultural areas a single satellite estimate may be more representative than two conventional observations within the area.

The approach chosen to obtain temperatures for agricultural monitoring is through the operational atmospheric soundings. The enhanced sounding processing provides temperature and moisture soundings for 3- by 3-pixel arrays of the high resolution infrared radiation sounder 2 (HIRS/2) instantaneous fields of view (IFOV's) giving a ground resolution of about 75 kilometers at nadir. Canopy temperature is simply the moisture corrected brightness temperature observed in an atmospheric window channel of the HIRS/2. If the radiating surface of the Earth is covered with vegetation, then the surface is a plant canopy. Of course, the IFOV for the HIRS/2 is so large that the radiance measured is from a mixture of surface types (water, bare soil, crops, and native vegetation).

Shelter and dewpoint temperatures are obtained by regression using the Television Infrared Observation Satellite (TIROS) operational vertical sounder (TOVS) data and sounding products as predictors in the equations. Figure 12 shows satellite estimates of shelter temperature compared with observed values from NOAA-6 soundings. The results shown are for clear and partly cloudy conditions during spring and summer. The error increases for cloudy retrievals (microwave) and during the winter.

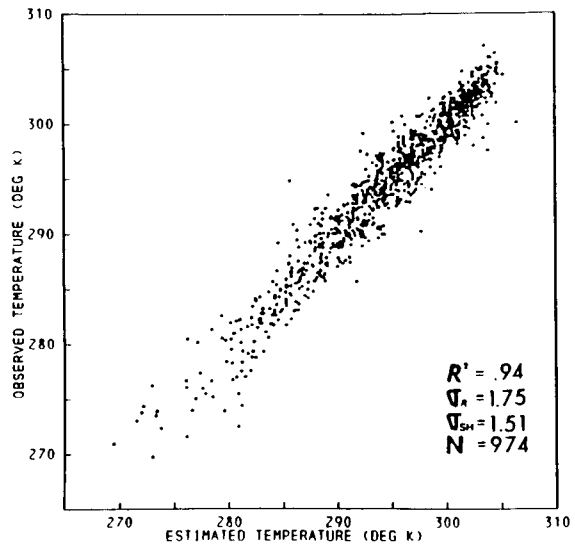


Figure 12.- Shelter temperature plotted against satellite estimates for clear and partly cloudy retrievals for April through July 1981.

Estimates of maximum and minimum temperatures are obtained by regression against shelter temperature, local solar zenith, and cloud cover. The overpass times of the daytime polar orbiter (NOAA-7) at 0230 and 1430 local time are near optimum for estimating the daily maximum and are good for estimating the minimum.

Since the maximum and minimum temperature estimates are liable to considerable error, the experimental temperature product being prepared for USDA is a blend of satellite and surface temperature observations, with greater weight given to the conventional measurements. The satellite values enter the field where conventional data are sparse.

As part of the agricultural monitoring program, interactive and fully automated techniques are being developed for analysis of precipitation over major crop growing regions. A manual method was

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developed into an interactive method which uses mapped NOAA AVHRR data, climatic rainfall analyses, and convective cloud and rainfall observations from the global telecommunications system. The objective is to obtain a more accurate distribution of daily rainfall than was previously possible with convective rain gauge data. A meteorologist analyzes a cloud type field based on interpretation of the rain clouds observed in the visible and infrared satellite imagery. The computer uses the climatic rainfall analyses and global regression equations to estimate the rainfall between satellite passes. An example of a field of precipitation estimates superimposed on cloud imagery is shown in figure 13.

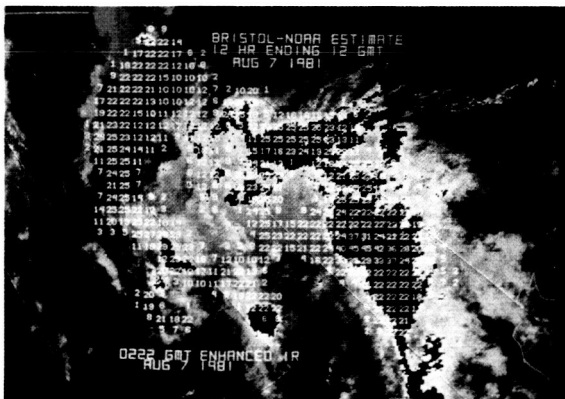


Figure 13.- A field of precipitation estimates superimposed on cloud imagery for a mapped AVHRR scene.

A second method uses similar input data on a more automatic approach where the AVHRR infrared temperatures are converted directly into precipitation estimates. In this method, the analyst edits the resulting precipitation field. In the two procedures discussed above, the most important responsibility of the meteorologist is to interpret and analyze for the development or dissipation of rain clouds during the 6- or 12-hour period between passes.

The third technique developed uses hourly GOES infrared images for automatically tracking and measuring the growth of convective cloud systems. The estimates are automatically generated for crop growing regions and are transferred for climatic adjustments and editing on interactive equipment.

Houston, Texas

Considerable effort has been made to develop a practical method of computer screening cloud-contaminated pixels from satellite data. A simple Fortran subroutine has been developed that can quickly and efficiently perform a hierarchical classification of NOAA-7 AVHRR data into clouds, haze, water, bare soil, and vegetation. The subroutine uses data from all five AVHRR bands in a hierarchical series to obtain the classification results. The approach allows the subroutine to adjust automatically for time of year and scene location. Bands 3 and 4 are used to detect the presence of haze. Bands 1 and 2 are used to detect clouds and to classify cloud-free data into water, bare soil, and vegetation. The approach developed for NOAA-7 AVHRR data should be amendable to other satellite-sensor systems.

The increase of atmospheric haze caused by volcanic eruptive products, as measured by the NOAA-7 AVHRR data, was demonstrated. Prevailing nadir atmospheric transmission, measured on the ground at Weslaco, Texas, before the El Chicon volcano eruption was 0.686, and afterward it was 0.611. This represents a decrease of 10.9 percent (fig. 14). The decrease of atmospheric transmission measured on the ground agreed with increases of NOAA-7 AVHRR digital count minimum (DCM) values in the visible and infrared bands obtained over the Gulf of Mexico. The DCM's ranged from 17 to 37 before, as compared to a range of 45 to 116 after, the eruption. These results demonstrate

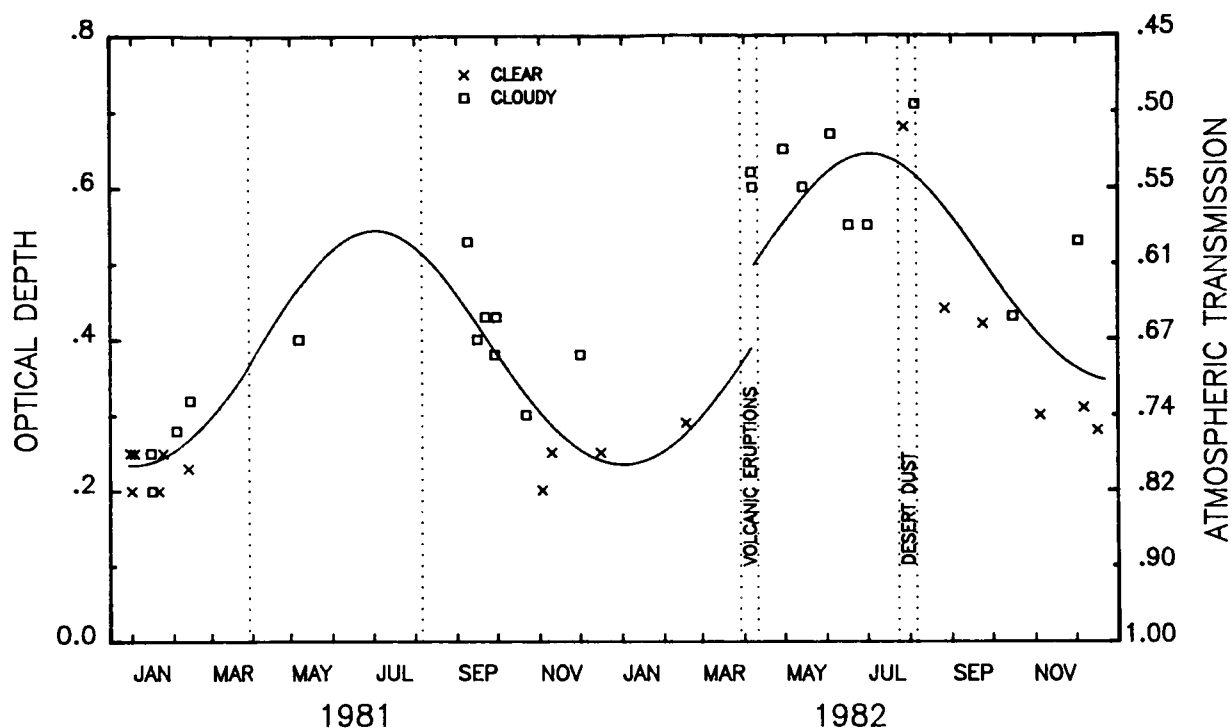
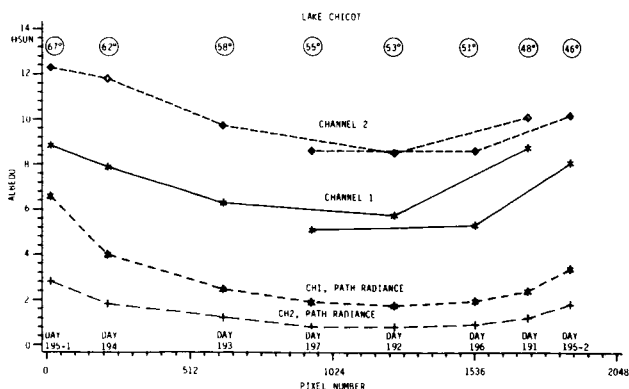


Figure 14.- Prevailing nadir atmospheric transmission, ground-measured, and NOAA AVHRR minimum digital counts before and after the El Chichon Volcano eruptions.

the importance of monitoring NOAA-7 AVHRR DCM's for transient atmospheric haze effects that could potentially interfere with early warning crop stress detection activities.

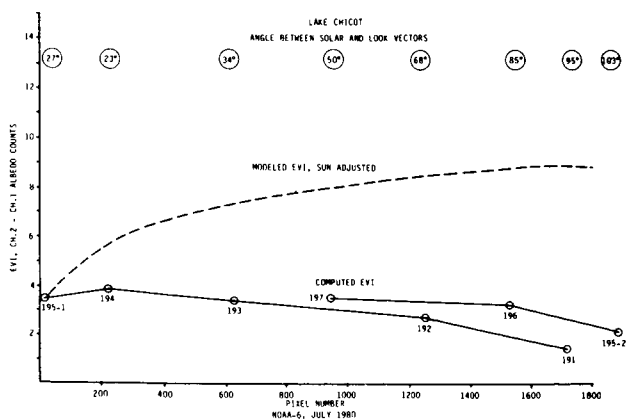
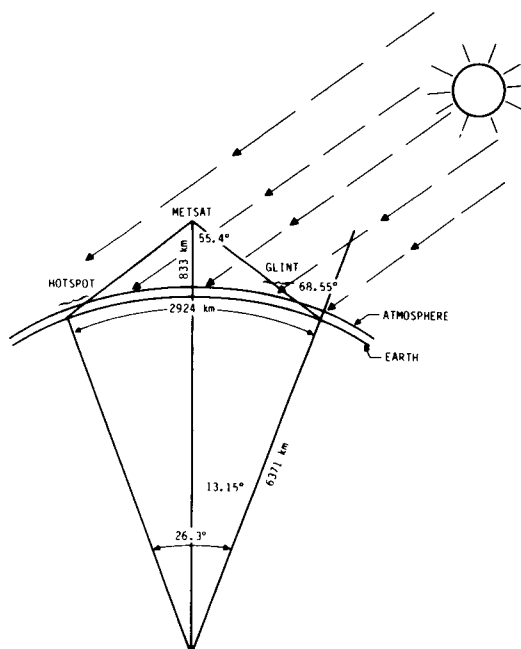
Another study researched the effects of solar illumination, view angle, and non-Lambertian surfaces on NOAA AVHRR sensor data. Figure 15 summarizes the results of applying geometric and solar corrections to the data. Results indicate that useful greenness information can be derived using data up

to about 512 pixels either side of nadir. The effect of non-Lambertian surfaces becomes apparent when considering the angle differences between insolation and the satellite viewing vectors. It is suggested that the increased shadowing with increasing pixel numbers plays a significant role in the interpretation of data from non-Lambertian surfaces. The findings also show that solar zenith corrections (dividing AVHRR data by the cosine of the sun zenith angle) are not necessary when computing vegetation index numbers (VIN's).



(a) Radiance values as influenced by scan angle (pixel number) for channels 1 and 2 of the NOAA-6 AVHRR sensor.

(b) Geometric relationship between the Sun and the AVHRR scanning limits with respect to the Earth.



(c) Modeled EVI's (Lambertian surface) and computed NOAA-6 derived EVI's illustrate the atmospheric and illumination geometry effects. Simulated data were derived using Dave's data set.

Figure 15.- Geometric and solar correction of NOAA AVHRR data.

4.2 INVENTORY TECHNOLOGY DEVELOPMENT/SUPPORTING RESEARCH

The general objectives of the ITD/SR projects during FY 1983 were to research, develop, and test space remote sensing technology in order to better understand the characteristics of vegetation-related features of the Earth's surface, and to develop methods for observing and analyzing these data and for extracting information about the Earth's surface, nature, and dynamics. The FY 1983 research was expanded from previous years' work on crop specific techniques to include research on all types of vegetation and global surveying applications. The ITD/SR projects are managed by NASA with participation by USDA and NOAA.

The ITD/SR research expands and improves upon the remote sensing technology developed in previous years, and beginning in FY 1983, it focused on corn/soybeans identification, vegetation mapping, TM, AVHRR, microwave and soils research, and estimation of biophysical characteristics.

4.2.1 Technical Objectives

The FY 1983 technical objectives were focused on the following:

- The testing of a crop temporal profile technique for corn/soybeans identification in Argentina.
- An evaluation of the use of TM data for corn/soybean identification.
- An evaluation of the use of TM data for land cover separability.
- An assessment of the capabilities of the AVHRR for vegetation monitoring.
- A determination of the spectral separability of forest species by different sensors.
- Continued research in the determination of quantitative relationships between soil properties and spectral response.
- Research and development on the estimation of biological productivity - especially forests, grasslands, and cultural vegetation - from remote sensing.

4.2.2 Corn/Soybean Identification

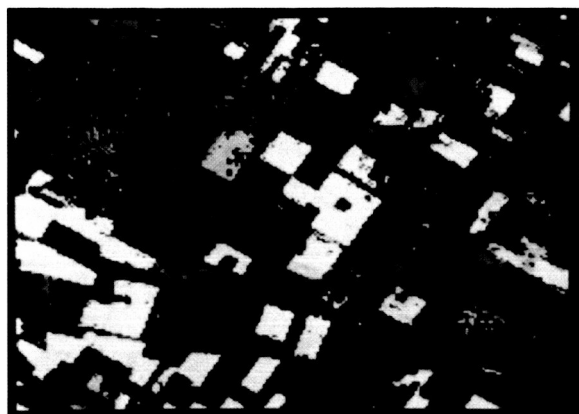
Argentina

A crop temporal profile technique was developed during 1982 to permit multirate Landsat spectral data to be interpreted in terms of key vegetation growth parameters. The resultant parameters, such as date of emergence, peak greenness, length of the growing season, and maturity stage, can be uniquely related to specific crop types.

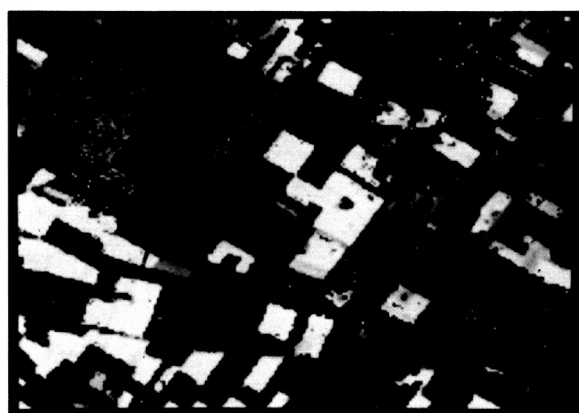
A typical crop temporal profile uses three features - the maximum value of greenness, the time distance between inflection points of the fitted profile, and the time of peak greenness - to automatically label and separate corn and soybeans using Landsat spectral data. As reported in the 1982 AgRISTARS Research Report, the relationship between these features and crop type was shown to be stable for corn and soybeans over large areas of the United States for 3 consecutive years. The higher accuracy for crop identification and proportion estimation obtained using this technique needed only to be tested in a foreign corn/soybeans region.

During FY 1983, this technique was applied to six segments in Argentina using Landsat-2 and Landsat-3 MSS data.

The same three profile features used in the U.S. study provided corn and soybean discrimination in Argentina. Results on Argentina segments using the automated profile technique gave a crop proportion estimate within 2 percent of those results using ground-truth labels (fig. 16).



(a) Results obtained by using ground-truth labels for corn, soybeans, and other crops to train the temporal profile classifier.



(b) Results obtained by automatically training the profile classifier using decision rules developed over only four segments within the United States.

Figure 16.- Classification results, segment 0682, Salto, Argentina.

Iowa

A multitemporal set of TM and TM simulator (TMS) data for Webster County, Iowa, was converted to TM greenness, and the multispectral profiles extracted were the same as those used with MSS data in the Argentina test. The profile features were found to be the same using MSS and TM data, and the performance accuracy was, on the average, 8 percent higher using TM data compared with MSS data. The increased accuracy was the result of a combination of better resolution, improved wavelength coverage, and a better S/N ratio.

Figure 17 shows the results of the TM classification: red is corn, blue is soybeans, and black is everything else. Figure 18 shows the areas of disagreement between ground survey data and classification results for soybeans. Red, pink, and green are the only areas of disagreement. The classification accuracy for corn is 96 percent and for soybeans is 90 percent.

It has been demonstrated that the same profile features apply in four years from 1978 to 1982 for two different sensor systems and two different countries.

Previous analyses of TMS data have shown that bands 1 through 4 of the TM are not optimum for the separability of corn and soybeans in Iowa in early August, but the mid-infrared bands provide additional separability during this period. An analysis of the three TMS scenes and three TM scenes acquired over central Iowa was undertaken to test these earlier findings and to determine both the additional amount of information provided by the mid-infrared spectral bands throughout the crop year and the effect of the increased TM quantization levels on corn/soybeans separability.



Figure 17.- A color-coded classification map of a TM scene. Red = corn; blue = soybeans; black = other.

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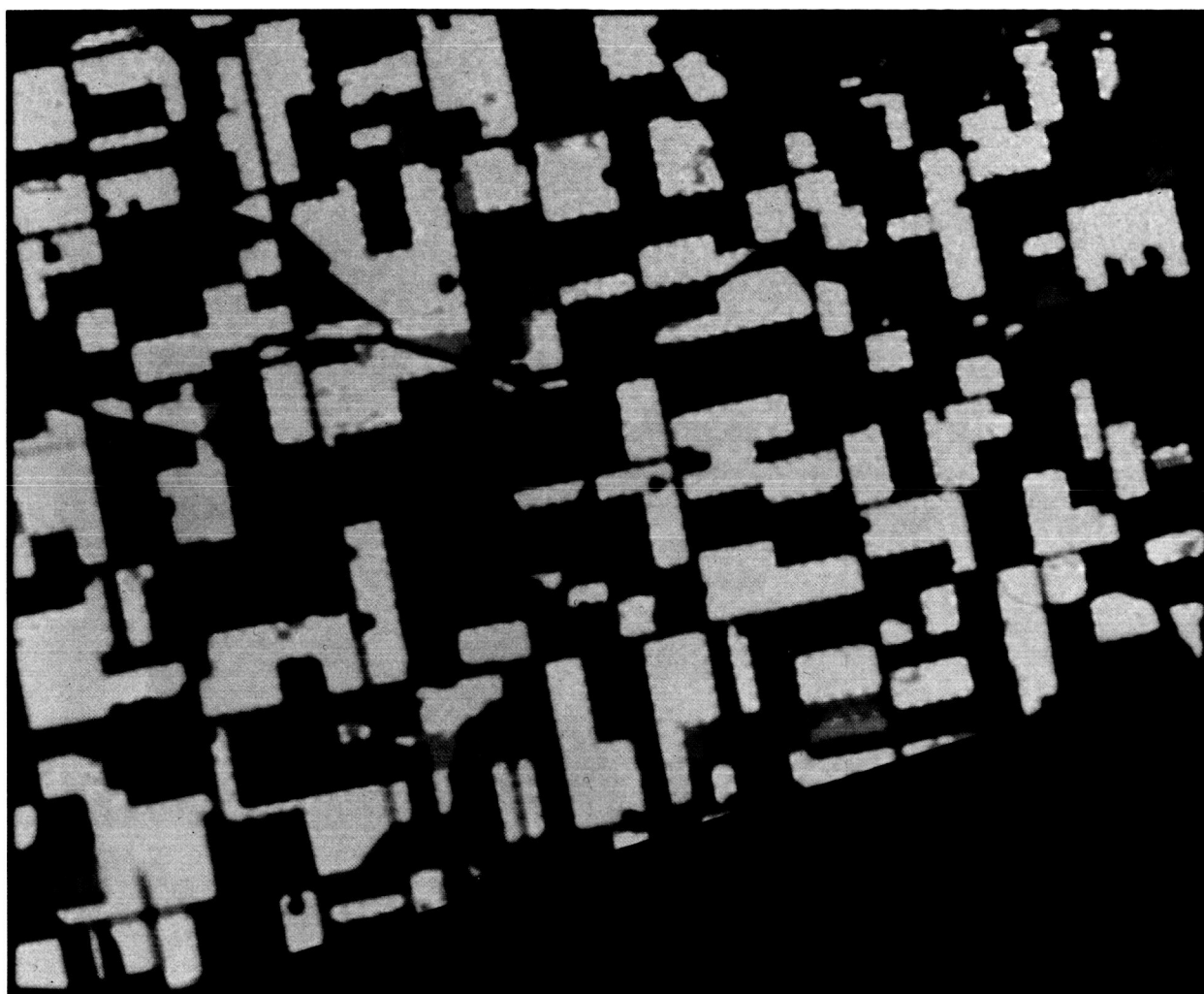


Figure 18.- A color-coded misclassification map of a TM scene. Yellow = complete agreement between corn and soybeans; green = ground survey soybeans missed by classifier, blue = ground survey corn; pink = ground survey corn called soybeans; and red = classifier-called soybeans called other by ground survey.

The separability measure used in this study was the Fisher Information function. It was calculated using all seven spectral bands and the four visible and near-infrared bands. A value of 1.0 for this function indicates that two species are completely distinguishable and a value of 0 indicates that no separability exists. Figure 19 shows that September 3, 1983, was the best separability date using only the visible and near-infrared bands. The mid-infrared bands provided a separability on July 31, 1983, comparable to that on September 3, 1983. This result corroborates previous results using 1981 helicopter spectrometer data over this same sample

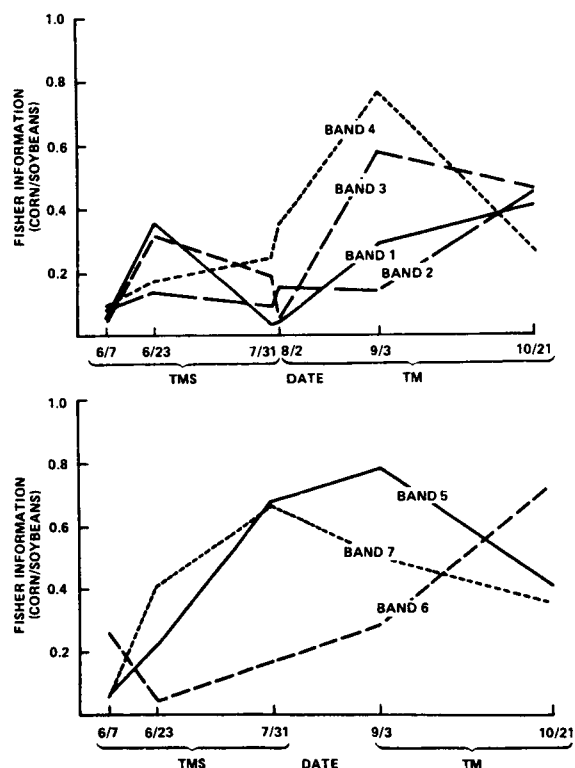


Figure 19.- Separability results for corn and soybeans using the Fisher information function on multi-temporal TM and TMS data over Webster County, Iowa, 1982.

segment. Early in the crop year (June 23), bands 1 and 3 (blue and red) were the best single bands. Later (August 2), bands 5 and 7 (mid-infrared) were best. In early September, both the mid-infrared and near-infrared (bands 4 and 5) were best. During harvest (October 21), the thermal (band 6) was the best single band.

4.2.3 Land Cover Separability

Planned research using TM data was impacted by the loss of the sensor acquisition capabilities. However, extensive single-date analysis in class separability was achieved from data acquired on August 22, 1982, over northeast Arkansas. An assessment of the relative contributions of the reflective bands (the TM thermal band was not included) to separabilities was completed. The basic data set consisted of four study sites which represented a wide variety of crops, land cover types, and range of conditions.

From these sites, approximately 1600 pixels that were ground verified were submitted to feature separability and subsequent classification algorithms. All possible band combinations were analyzed. Figure 20 represents the overall results achieved: (1) all bands; (2) the best three-band combination; and (3) the MSS "equivalent" bands for the 21 different categories. Figure 21 depicts the results from all three-band combinations. The primary result from these analyses revealed that performance was most sensitive to the inclusion or exclusion of bands 4 or 5.

The results of these experiments were achieved from a single data set, at a single acquisition period, and at conditions specific to that geographic region and time period. However, these caveats can also be viewed as components of a "worst case" situation, whereas a substantial number of classes (21) with

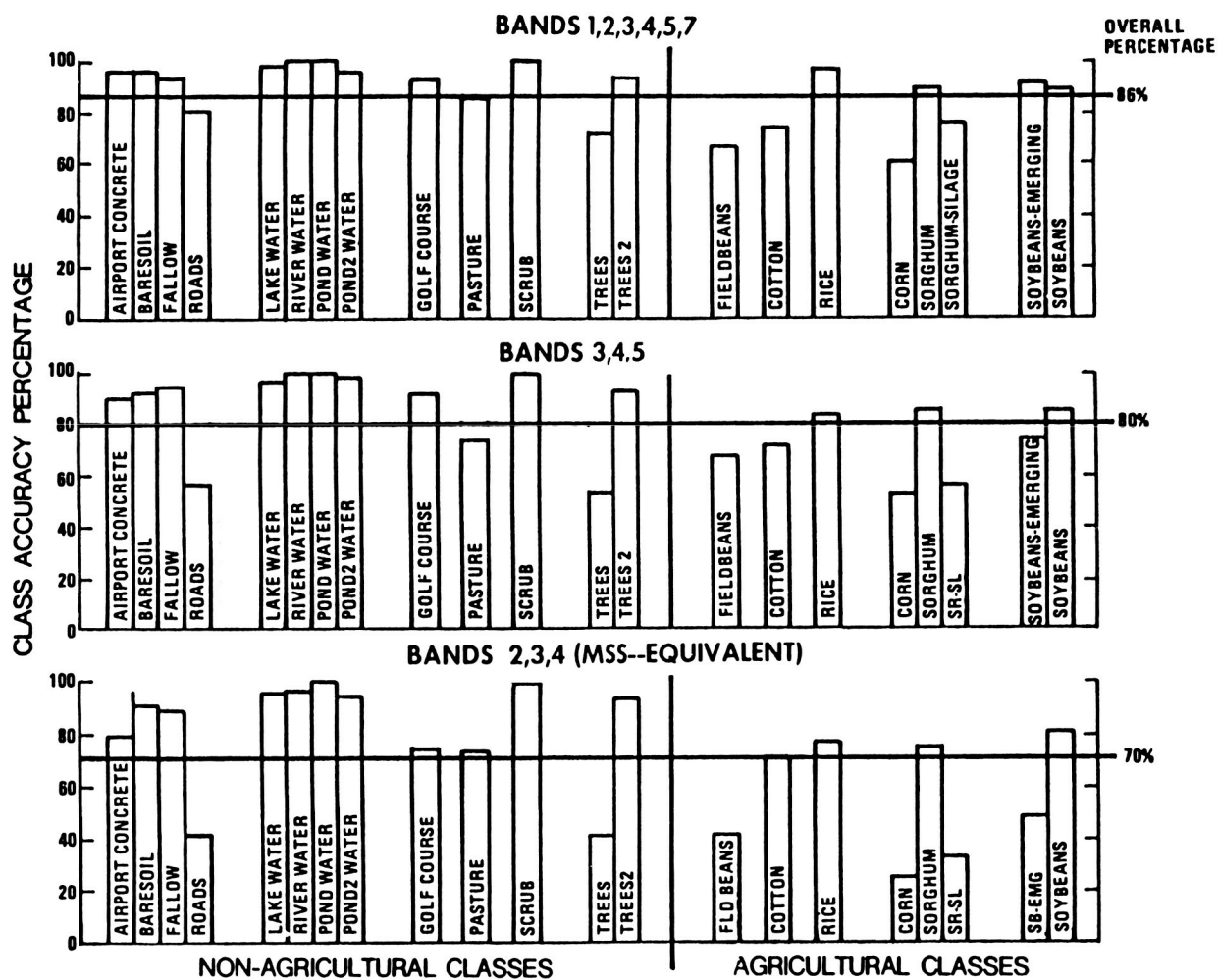


Figure 20.- Single-date TM analysis of Arkansas scene, August 22, 1982.

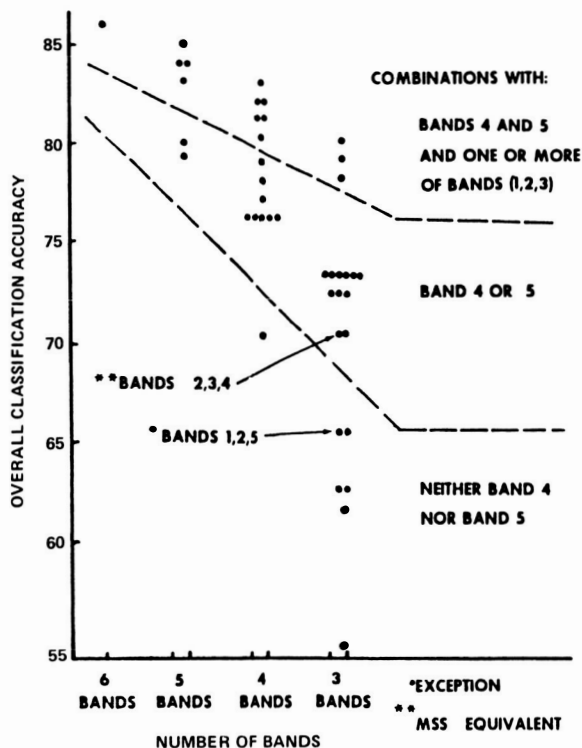


Figure 21.- Band combination analysis using single-date data, Arkansas scene, August 22, 1982.

single-date data achieved separability performances comparable to previous results with MSS over a smaller number of classes that required multitemporal data.

In another study in northeast Oklahoma, supervised, maximum-likelihood classifications of Seasat, Shuttle Imaging Radar A (SIR-A), and Landsat pixel data demonstrated that SIR-A data provided the most accurate discrimination (72 percent) between five land cover categories - cropland, pasture, forest, water, and urban. Furthermore, spatial averaging of the synthetic aperture radar (SAR) data significantly improved classification accuracy because of a reduction in the effects of both fading and natural, within-field variability. As expected,

multisensor classifications of field-averaged data show that the addition of L-band radar to Landsat data significantly improves classification accuracy (figs. 22 and 23).

4.2.4 AVHRR Vegetation Monitoring

The investigation to assess the capabilities of the AVHRR for vegetation monitoring has focused on the development of technology as well as on an evaluation of the sensor's information content to provide a synoptic view that will permit the classification of the land surface into regional-level major ecosystem classes. Procedures that estimate or correct for the atmosphere have been evaluated. Thus, a good understanding of the conditions and limitations

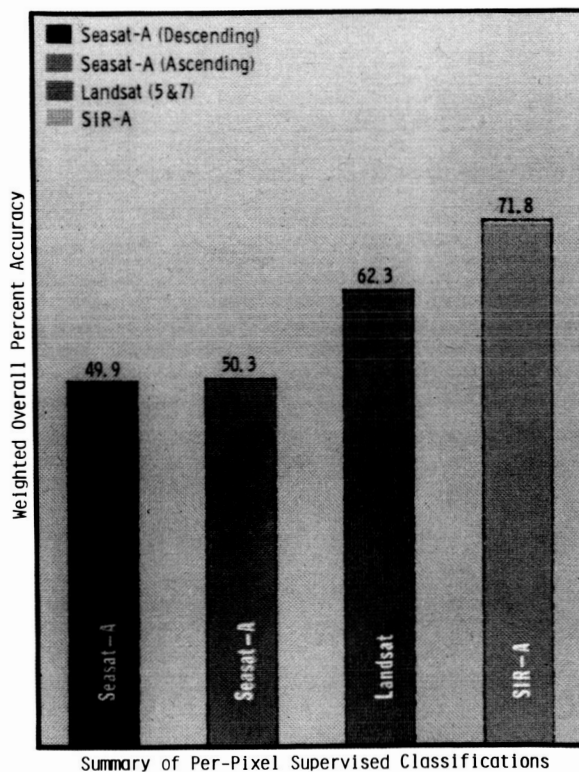


Figure 22.- Accuracy of per-pixel supervised land cover classifications of northeast Oklahoma.

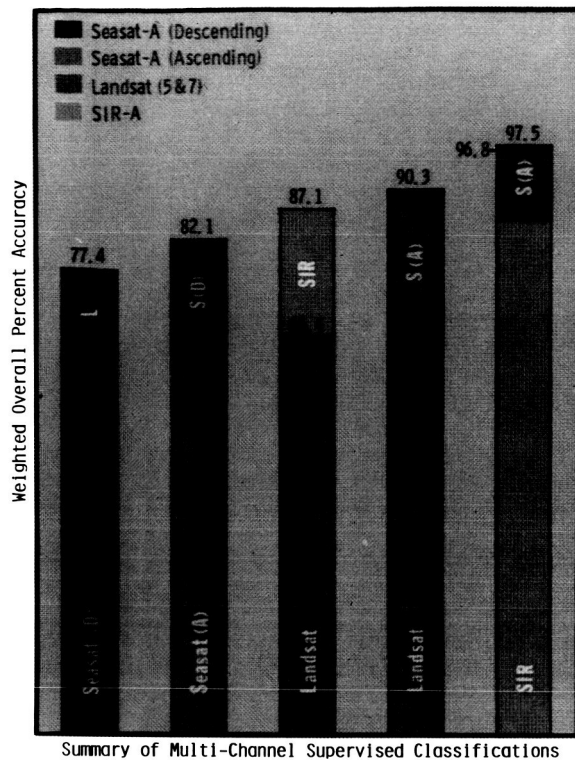


Figure 23.- Accuracy of field-based single and multichannel supervised land cover classification of north-east Oklahoma.

for use of the sensor has been attained (fig. 24). Preliminary analyses have also been performed to estimate the feasibility of using AVHRR data to distinguish land surface characteristics for use in a multistage sampling approach to land cover inventory and mapping. Results generally indicate that good separability exists between Level 1 Anderson land use classes.

The AVHRR ground track progresses from west to east, so that with daily acquisitions, multiple viewing angle data may be obtained. Because of the non-Lambertian nature of the surface, different amounts of shadow are viewed at different angles, providing either a source

of noise, if it is desirable that the scene appearance be independent of view, or a source of information, if the desire is to determine characteristics of canopy structure from these data. Figure 25 shows the pattern of change in the Gray-McCrary Index (GMI), AVHRR channel 2 - channel 1, for five scenes as the NOAA-6 AVHRR moved across the scene over 6 consecutive days, July 9-15, 1980. In this figure the sun is to the right, and pixels numbered near zero are to the far west end of the scan. Differences in the patterns of pine, hardwood, and crops indicate there is information concerning the nature of the canopy in multiple viewing angle data. In this figure the dashed curve represents the effect of viewing angle on a Lambertian model, with a light haze atmosphere indicating how poorly the Lambertian assumption simulates the radiative properties of these vegetative surfaces.

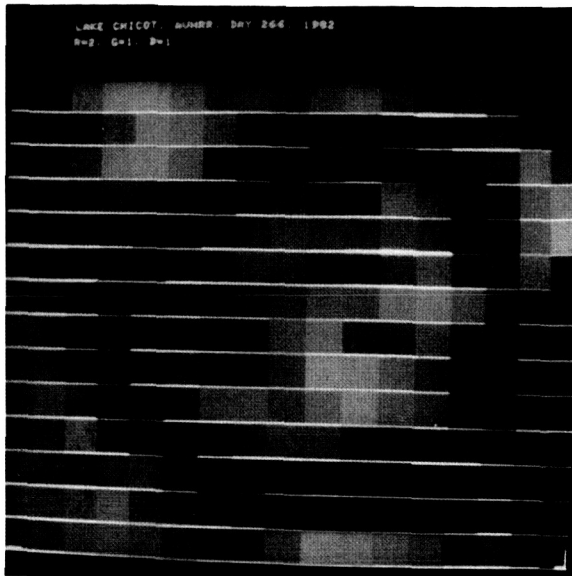
4.2.5 Forest Species Separability

Remote sensing data can be used to stratify a scene into its various structurally distinct categories prior to estimating LAI or other biophysical characteristics. In anticipation that the relationships between LAI and reflectance might be species dependent, a number of studies were conducted to determine which species might be spectrally distinct.

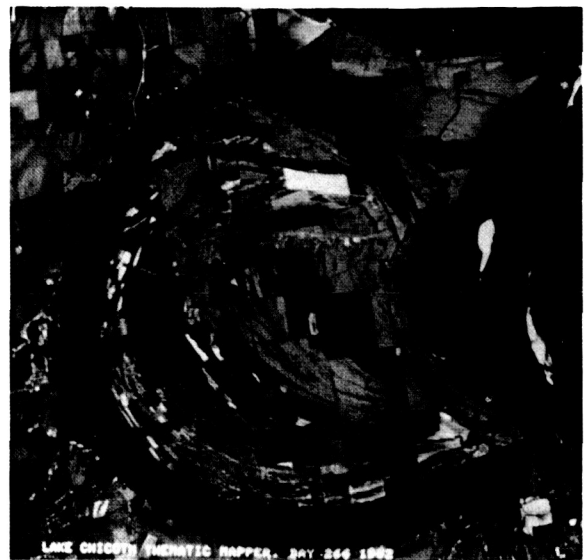
Landsat MSS data and aircraft TMS data acquired over test sites within the Superior National Forest of Minnesota were analyzed using a clustering algorithm, CLASSY. CLASSY was specifically designed to determine the spectrally distinct components of spectral reflectance data.

Five distinct classes appeared in the MSS data and fifteen distinct classes appeared in the TMS data. Higher spatial resolution and a larger number of spectral bands account for the increase

ORIGINAL PAGE
COLOR PHOTOGRAPH



(a) AVHRR.



(c) TM.



(b) MSS.

Figure 24.- A three-sensor view of Lake Chicot, Arkansas, September 23, 1982.

in the number of distinct classes appearing in the TMS data. In the MSS data black spruce was confused with jack pine, but it was separable from aspen. In the TMS data, all classes observed in the

MSS data were distinguishable. In addition, classes not distinguishable in the MSS data, such as brush areas, bogs, aspen-pine mixes, and burn areas, were distinguished in the TMS data.

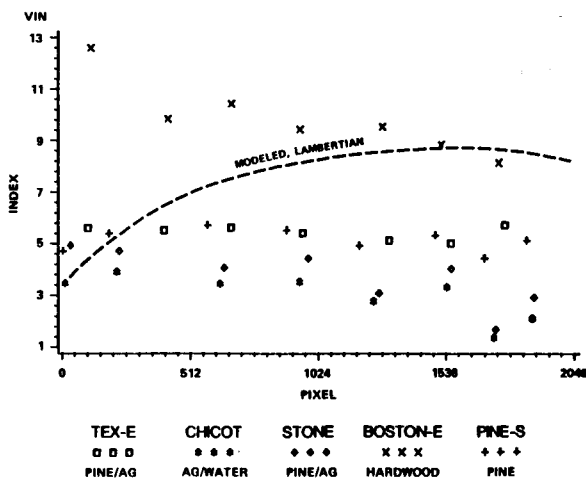


Figure 25.- AVHRR view-angle effect on vegetative index (channel 2 - channel 1).

The Fisher Information function was used to quantify the spectral separability of the various boreal forest species. This function is a measure of the overlap in spectral space between the spectral reflectance distribution functions found by CLASSY for the various species in the scene. In general, the conifers (black spruce and jack pine) are very distinct from the deciduous trees (birch and aspen). However, species within the conifer and deciduous categories are not very separable. Hence, other dates, bands, and multitemporal data will be explored to ascertain the separability that may be achieved.

Another study was conducted using TMS for assessing northern forest cover types. The objectives were to determine those TM wavebands most useful for differentiating northern forest cover types, and to obtain a baseline assessment of classification accuracy due to waveband combination (fig. 26). TMS data and coincident aerial photography were collected over a 23,200-hectare forested area near Baxter State Park in north

central Maine. The results of the discriminant analyses suggest that useful waveband combinations include at least one band from the visible (0.4 to 0.7 millimeter), and one band from the mid-infrared (1.3 to 3.0 millimeter) spectral regions. The blue band proved most useful for discriminating coniferous defoliation categories, especially in differentiating healthy conifer stands from those damaged by the spruce budworm. An analysis of the classification accuracies indicated that most of the useful spectral information was contained in the first three bands. The two mid-infrared bands provided significant spectral information for differentiating all cover type groups considered. The second mid-infrared band proved most useful for coniferous defoliation assessment, while the first proved most useful for differentiating all cover types.

Three of the four most useful wavebands for discriminating northern forest cover types (bands 1, 5, and 6) are not available on the Landsat-1 through

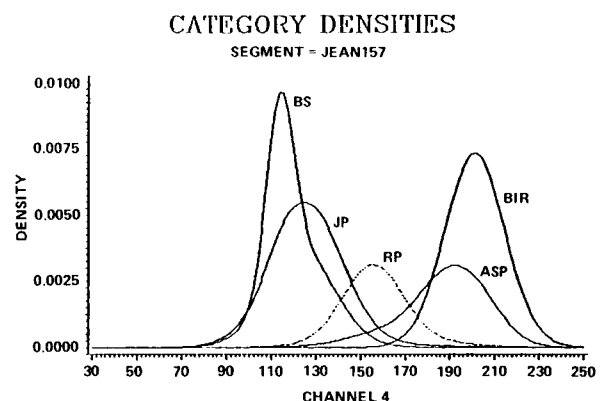


Figure 26.- Spectral separability results for tree species within the boreal forest of Minnesota, using the Fisher information function on channel 4. BS = black spruce, JP = jack pine, RP = red pine, BIR = birch, ASP = aspen.

Landsat-4 MSS's. Hence, significant improvements may be expected in the ability to spectrally differentiate the more detailed land cover categories using TM data.

Another study was designed to determine the information content of the TMS data acquired over the Clearwater National Forest, Idaho. Supervised and unsupervised classifications were performed on the TMS data to evaluate the use of conventional, "on-the-shelf" techniques for extracting land cover resource information.

Results from the TMS analysis revealed that the use of conventional digital image processing, incorporating maximum likelihood classification, provides a readily available technology for TM data analysis. In addition, it was found that the increased number of spectral channels on TM were of significant value in improving classification accuracy. Additional findings from this analysis were: (1) TMS 7-channel, 30-meter, 8-bit radiometry yielded a higher classification performance than did 3-channel, 60-meter, 6-bit MSS-like data; (2) optimal channels for forest structure discrimination are from a wide range of the electromagnetic spectrum (visible, near-infrared, mid-infrared and thermal); (3) manually interpreted color composites of channels 7 (thermal), 4 (green) and 2 (blue) provided the best results for forest structure discrimination; and (4) the increased level of scene noise due to the increased spatial resolution of TM data may degrade per-pixel classification performance; therefore, techniques such as contextual classifiers, spatial data aggregation, and logic models should be evaluated as methods to more fully utilize TM data.

The East Texas Radar Experiment has a long-term objective, the goal of determining how well various classes of vegetation can be separated in a southern

temperature forest. Classes of forest characterized by species, age, and stand density were selected as a test bed for this research. The short-term objective is to use scatterometers (nonimaging radars) for selection and design of imaging radars. Aircraft flights in September 1981 provided data from multiparameter scatterometers; multi-mode, X-band SAR; TMS; and color infrared photographs. Landsat MSS data were obtained earlier. The multiparameter scatterometer data have been analyzed using a simple single-feature, two-class separability measure. L-band (20-centimeter) cross-polarized data, horizontally acquired/vertically transmitted (HV), are useful for separating trees from other features and for discriminating between individual tree classes and non-tree classes, such as clearcut and grassland. Separability between various tree classes is best demonstrated by C-band (6-centimeter), cross polarization (HV). Figure 27 shows radar backscatter in decibels plotted against the number of readings for pine and hardwood classes. The classification error rate for these two classes is above 14 percent.

The multiparameter scatterometer data have also been analyzed using linear

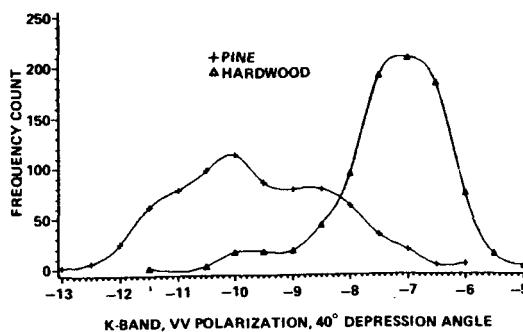


Figure 27.- Radar backscatter histogram: pine versus hardwood.

discriminant analysis, which is a multi-class, multifeature classifier. Higher frequency (C-band and Ku-band) gives the best overall classification accuracy, on the order of 50 percent; the addition of another frequency or polarization increases the classification accuracy to about 64 percent, while use of multiple angles further improves the accuracy to about 72 percent. The vertical transmit polarization seems to be very important in achieving good overall classification accuracy.

The X-band SAR data require digital preprocessing to obtain better quality images. In addition, the airborne TMS measurements must be preprocessed to conduct a synergistic study of optical and microwave data for forest classification.

4.2.6 Soils Research

The soils research effort is directed toward developing quantitative relationships between soil properties and spectral response to estimate specific soil physical, chemical, and interpreted properties related to biological productivity, biogeochemical cycles, and hydrological cycles.

Within the past year significant progress was made in the soils area. Laboratory soil reflectance measurements were used to simulate Landsat MSS digital counts for clear and turbid atmospheres and were found to be within the range of values for soils seen in Landsat data (fig. 28). Reflectance curve forms representing genetically homogeneous soil properties were found to be separable in greenness and brightness vector space. Organic matter content could be stratified into 0- to 2-percent and greater than 2 percent, with 80 percent accuracy. This technique of converting reflectance data from controlled experiments to simulated Landsat digital counts will enable researchers to

LABORATORY REFLECTANCE - NO ATMOSPHERE

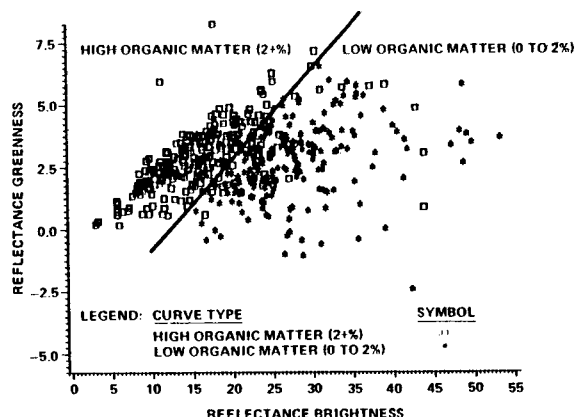


Figure 28.- Location of reflectance spectra curve types of high and low organic matter in greenness and brightness vector space.

account for the effect of soil on vegetation-spectral relationships, to conduct sensitivity analyses of the effect of soils on spectral models, and to develop a better understanding of the relationships of spectral and physical-chemical properties of soils.

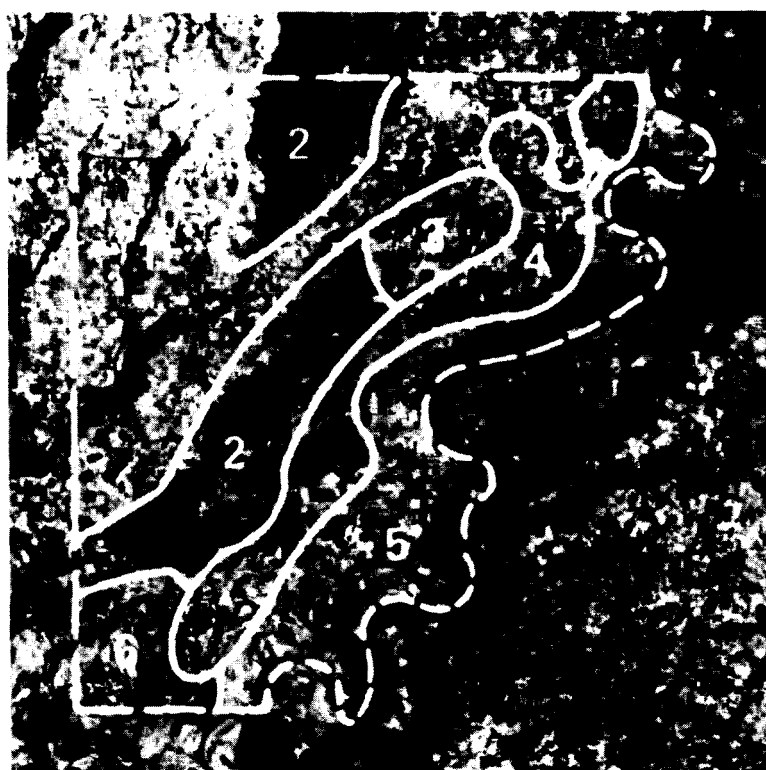
Landsat TM data acquired over two different regions (Mississippi River alluvium and glacial till in Webster, Iowa) were evaluated to assess field soil effects on vegetated landscapes and to determine whether TM spectral bands provide information for soil association maps. Results from these studies indicate that the TM provides information which is related to the soil properties. Within the alluvium, the most useful bands for identifying soil association boundaries located by USDA's general soil maps (see fig. 29) were the 0.76 to 0.90 millimeter, the 1.55 to 1.75 millimeter, and the 10.4 to 12.5 millimeter. Within the glacial till region, aircraft TMS and Landsat-4 TM data acquired over soils ranging from bare to fully vegetated cover indicated that key soil

properties (i.e., soil moisture regime) could be separated throughout the growing season. The September 3, 1983 TM data, even with a vegetated cover of greater than 90 percent, separated the soil moisture regimes with 72.5 percent accuracy for soils covered by corn and

68 percent accuracy for soils covered by soybeans. These results indicated that the improved spectral and spatial resolution of TM offers the potential to separate important soil properties, even in regions with similar soils and under a dense vegetation canopy.

MISSISSIPPI COUNTY, ARKANSAS

THEMATIC MAPPER (TM) DATA ACQUIRED AUG. 22, 1982



TM BAND 5, 1.55 - 1.75 μm

LEGEND GENERAL SOIL MAP

SOIL ASSOCIATIONS

- 1 Amazon Dunder Crevasse association: Poorly drained and somewhat poorly drained soils that are loamy throughout and excessively drained soils that are sandy throughout
- 2 Sharkey Steele association: Poorly drained soils that have a thick clayey subsoil and moderately well drained soils that are sandy in the upper part and clayey in the lower part
- 3 Sharkey Crowley association: Poorly drained soils that are clayey in some part of the subsoil
- 4 Tunica Bowdre Sharkey association: Moderately well drained and poorly drained soils that are clayey in some part of the subsoil
- 5 Convent Morganfield Crevasse association: Somewhat poorly drained soils that are loamy throughout and excessively drained soils that are sandy throughout
- 6 Alligator Earle association: Poorly drained and somewhat poorly drained soils that have a dominantly clayey subsoil

Figure 29.- TM band 5 overlaid on Mississippi County, Arkansas, general soils map.

4.2.7 Biophysical Characteristics Estimation

The distribution, dynamics, and composition of vegetative land cover are prime factors in the global energy balance. Vegetative evapotranspiration affects global circulation and patterns of precipitation and temperature. Biological productivity of land-related vegetation plays a key role in determining the amount of carbon dioxide in the atmosphere. Vegetation structure determines the ratio of runoff to storage and evaporation in the hydrologic cycle. Existing process models require a knowledge of the global distribution and dynamics of the attributes of land-related vegetation. Currently, this information is not very accurate or complete. Improvements in the estimation of vegetation characteristics, temporal changes, and distribution patterns are needed to provide an understanding of global processes. Remote sensing can provide critical inputs to process models which predict biological productivity and biomass based upon known physical and biological principles and remotely sensed parameters such as LAI, canopy temperature, and soil moisture.

The current research in biophysical characteristics has concentrated on the remote estimation of the biological productivity of forests, grasslands, and cultural vegetation, especially the relationships between plant structure and biophysical properties (LAI and biomass) and between radiometric and biophysical properties of vegetated canopies.

Three study sites were selected to represent each of the major biomes. The Superior National Forest near Ely, Minnesota, was chosen because it contained important species found in boreal forests - black spruce, aspen, and birch. The Konza Prairie near Manhattan, Kansas, is a tall grassland research area which supports long-term

ecological studies by the National Science Foundation. The Purdue University Agronomy Farm in Indiana was selected because of its capability for measuring biophysical properties and environmental factors affecting biological productivity under controlled conditions.

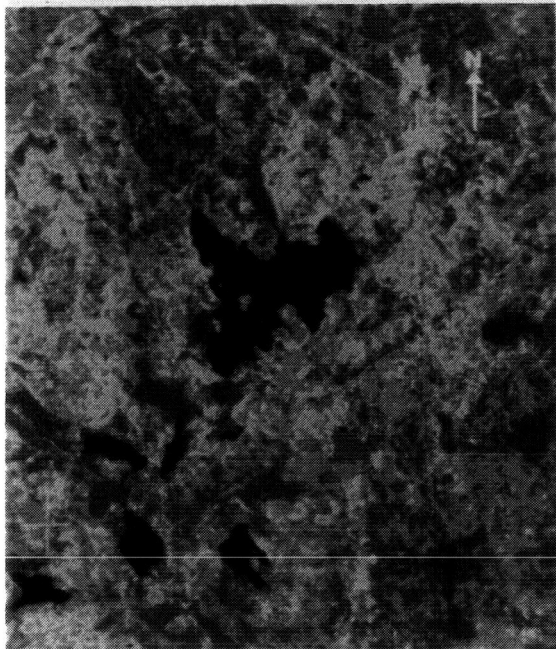
Although ground estimates of LAI are not currently available for the boreal forest site, theoretical studies indicate that canopy reflectance is strongly related to LAI, leaf optical properties, canopy structure, and background or understory. These studies suggest that LAI can be estimated from remotely sensed data and that:

1. The ratios of TM bands 4:3 and 4:5 are superior to greenness for the estimation of LAI because both are less sensitive to leaf angle distribution, understory reflectance, and sun zenith angle.
2. Multiple view angles should greatly improve the accuracy of estimation of LAI.
3. If only nadir view reflectance data are available, the LAI-reflectance relationships will be canopy structure dependent, so that the scene would need to be stratified into groups with similar structure prior to estimation of LAI. This might require classification of the scene into structurally similar classes (e.g., species) prior to biophysical characteristics estimation.

Use of the ratio of TMS counts in band 4 to counts in band 3 (4:3 ratio) to map vegetation density in a gross way was qualitatively evaluated over a portion of the Superior National Forest test area. A simple level slicing was applied to the 4:3 ratio values over this area. The result is shown in figure 30.

NASA-S-83-02401

NATIONAL FOREST LAKE JEANETTE AREA



JULY 13, 1983 THEMATIC MAPPER SIMULATOR

BAND 4
BAND 3 **RATIO IMAGE**

**VEGETATION DENSITY IS NOT
ALWAYS ACCURATELY
MEASURED BY 4/3**

BLACK	= WATER
RED	= LOW VEGETATION
DARK BLUE	= LOW DENSITY
LIGHT BLUE	= INTERMEDIATE VEGETATION
YELLOW	= HIGHEST DENSITY

Figure 30.- Band 4:3 ratio image of a TMS scene showing variation in vegetation density over a portion of the Superior National Forest. Lake Jeanette is in the center of the image.

Black corresponds to water. The lowest values of the 4:3 ratio are coded red, the next highest dark blue, then light blue, and finally yellow. Qualitative evaluation of this density map from aerial photography and helicopter surveillance indicates that red pixels generally correspond to bare ground or roads, as can be seen from Echo Trail outlined in red, winding across the center of the image and touching the tip of Lake Jeanette in the image center. Yellow generally corresponds to very dense stands (e.g., dense aspen). However, the intermediate level 4:3 ratio correspondence to vegetation density was species dependent. In some cases, what

appeared to be very dense black spruce stands had lower 4:3 ratios (dark blue) than did less dense aspen stands (light blue). It is likely that a scene will require stratification into structurally similar strata prior to application of the 4:3 ratio for vegetation density estimation.

In the Konza Prairie experiment, LAI measurements are already available, and as figure 31 shows, the bands 4:3 ratio tracks LAI throughout the season. Burned and unburned treatments were monitored in this experiment, and the two treatments can clearly be distinguished by the 4:3 reflectance ratio.

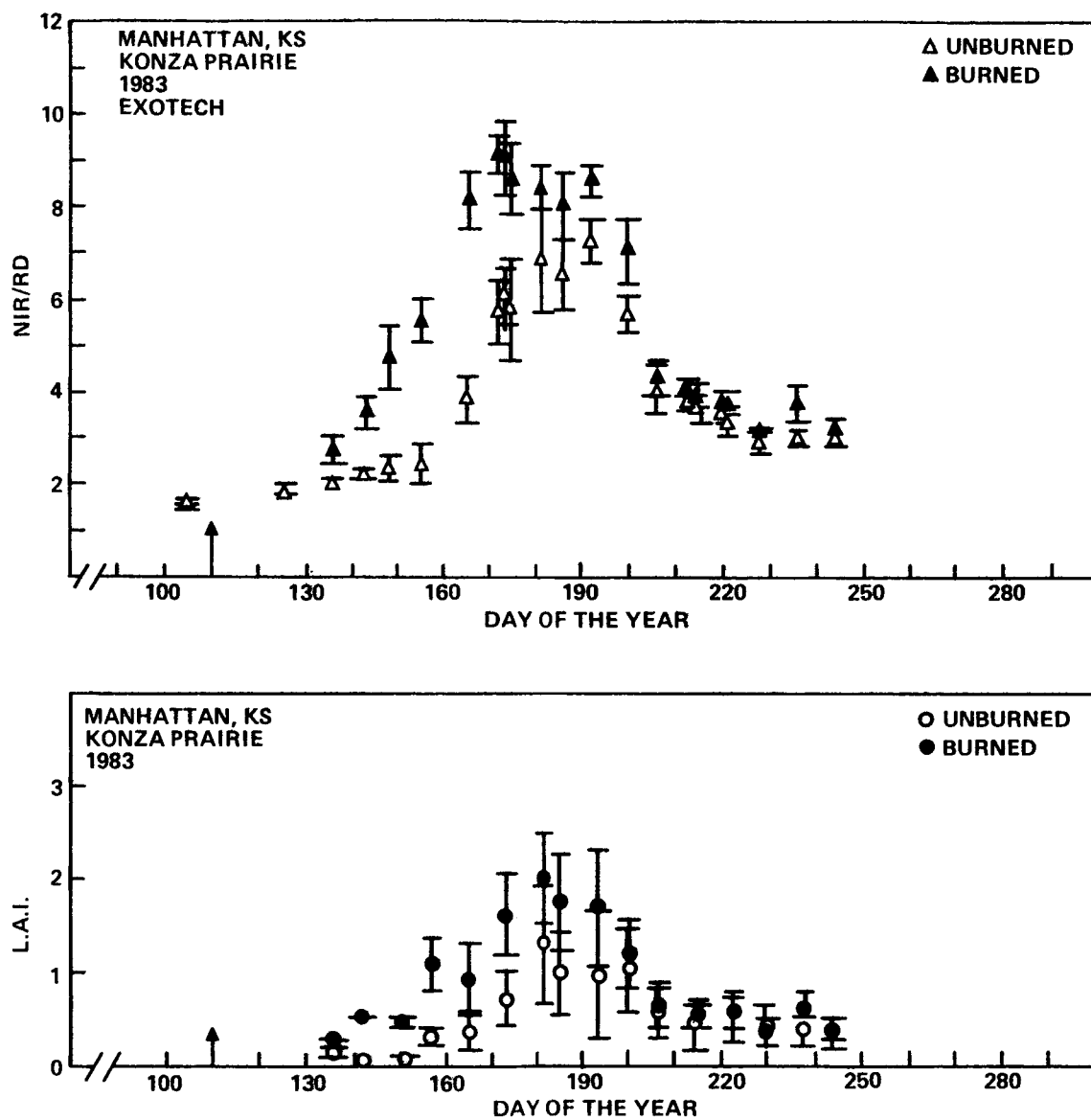


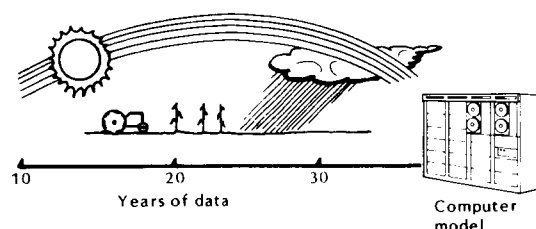
Figure 31.- Variation of the NIR/RD (band 4:3) ratio and leaf area index (LAI) during the growing season for unburned and burned control areas within the Konza Prairie.

4.3 YIELD MODEL DEVELOPMENT

YMD research utilizes the measurement of environmental and plant characteristics to project crop yield potential within a region. This effort is a key component of any commodity production forecasting methodology and, as such, contributes to both the domestic and foreign crop estimation processes. Research is jointly supported by NOAA/NESDIS, USDA/ARS, USDA/SRS, and staff support from NASA.

YIELD MODEL DEVELOPMENT

This is research to determine how various crops will respond to weather conditions, agricultural practices, and other factors. Many years of data are taken into account.



4.3.1 Technical Objectives

The FY 1983 objectives were:

- To test and evaluate candidate crop yield models.
- To develop new and improved crop yield models.
- To acquire, process, and store meteorological and satellite data appropriate for model development and testing.
- To conduct research on and to evaluate the use of satellite spectral inputs to yield models.

4.3.2 Yield Model Test and Evaluation

The initial phase of applying a set of test criteria to evaluate existing models is nearing completion. The models tested were of the type relating meteorological data to published yield series. These models, represented by the Center for Environmental Assessment Services (CEAS) and Thompson-type models, cover the crops of soybeans, corn, wheat, and barley. The evaluation consisted of internal model evaluation and comparative evaluation of the performance between models. In general, these models tend not to be sensitive to either extremely high or low yields. However, with the evaluation and documentation, they may be appropriate for a user's needs, provided the user is aware of the model limitations. Thus far in the AgRISTARS program, 47 reports have been issued concerning model comparisons and evaluations.

CERES-wheat is a wheat production simulation model developed for use in farm management, large area yield estimation, farm policy analysis, and identification of research needs. It was designed to account for the major factors influencing wheat yield, including weather, genetics, soil water, and sowing (time, depth, and rate), but excluding pests. The model runs with daily time steps and requires inputs of daily temperature, precipitation, and radiation. Genetic inputs are duration of growth stages, grain number, and grain weight. Soil inputs consist of water content at critical limits and factors influencing root growth. Stresses considered include plant water deficit and cold damage as they influence tillering, leaf and stem extension, assimilation rate, senescence, grain growth rate, and grain nitrogen.

To test the capability of the CERES-wheat model, 280 different data sets on wheat growth and yield were collected

from 25 sites throughout the world between 36°S and 50°N latitude. Published and unpublished data from agricultural experiments where weather, soils, management, and genetic data were available allowed testing the validity of the model for estimating phasic development, biomass production, LAI, soil water, yield, and yield components. Yield in the data set (given in kilograms per hectare) ranged from 380 at Bushland, Texas, to 9520 at Greoux, France (fig. 32). The correlation coefficient for estimated versus observed yields for the data set was 0.89.

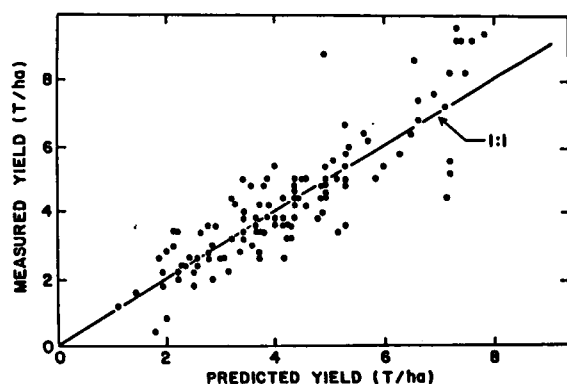


Figure 32.- A comparison of measured wheat yields with estimated yield using the CERES-wheat model for a diversity of environments.

The CERES winter wheat model was modified to produce operational yield estimates in the USSR throughout the growing season. The gridded meteorological data were provided to the NOAA/USDA Joint Modeling Center by USDA. The resulting yield estimates were returned for use in assessments. Ancillary data were also generated by the model, including stage of development (fig. 33).



S = sowing
E = emergence
H = heading
R = ripe
G = germination
J = jointing
D = dough
N = not planted

Figure 33.- CERES winter wheat model estimates of USSR spring wheat growth stages, July 31, 1983.

The model output was useful in assessing the wheat crop during the 1983 growing season as reported by FAS:

"The operation run of this model using weather data from 1981, 1982 and 1983 over the Soviet Union provided some very positive results that correlate well with information from the USSR and with other systems commonly used to produce yield estimates of winter wheat in the USSR

. . . The results of the model can only be described as good. This analysis is based on a set of circumstantial evidence and a very meager set of reported information from radio broadcasts or from newspaper articles. Most specific is the information from weather reports that place the crop calendar stages. This information generally placed the crop stage within a few days of those reported in the model. This became very satisfactory and in no area was the crop stage found to be more than five days

off. This was true for both the winter wheat and spring wheat models. The other piece of information deals with yield. A Rayon level yield of almost 30 C/ha was reported for Novomokiro Rayon in Denepropetropovlovsk Oblast. The model yield for this area is 29.7 C/ha. This is the only "ground truth" information on yield that could be used for a grid cell comparison. Although little ground truth information is available, yields calculated by the model were nowhere more than 1.5 C/ha different than those estimated by the analyst or those measured by the Vegetative Index Numbers.'

The CERES-maize model was tested and also became quasi-operational. The model was used in real time to evaluate the U.S. corn crop and the impact of the drought on corn yield. These indications were based on the weather data from 34 stations: observed data to date; forecast daily maximum and minimum temperatures for days of the coming week; and average temperature and precipitation beyond that point in time. The results of this effort and the comparison with the USDA within-season estimate indicate the model provided an early estimate of the low corn production (fig. 34).

The 1983 season was unusual. It started with a wet spring which delayed planting but which in some areas mitigated the effects of hot, dry July and August periods. The model forecasted 1983 yield reductions from 1982 levels of 31 percent to 55 percent in Illinois, Indiana, Iowa, Ohio, and South Dakota where very little corn acreage was irrigated. However, in Kansas and Nebraska where most acreage was irrigated, yield estimates indicated only slight reductions, if any, on irrigated acreage, but severe reductions on nonirrigated acreage.

The Texas A&M wheat model (TAMW) was also operational and available to

provide real-time assessments. These, however, were not run on an operational basis.

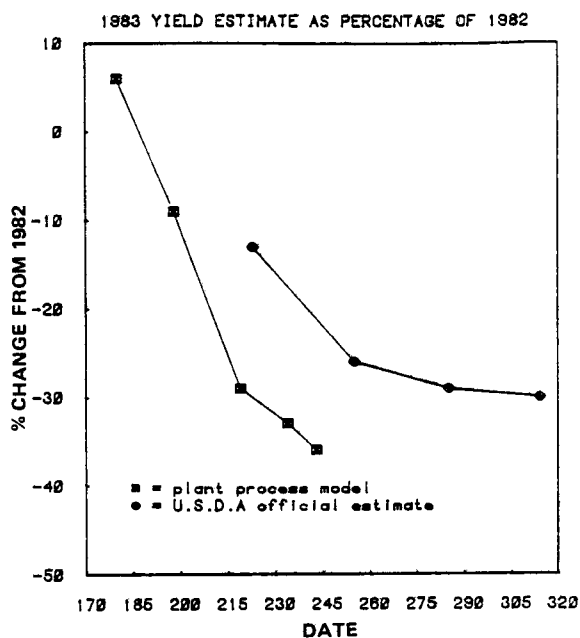


Figure 34.- Comparison of CERES-maize model yield estimates with USDA official estimates.

Phenology Models

Phenology models which estimate the stage of crop development are a vital component of plant process models. Because weather has a different effect on yield depending upon the developmental stage of the plant, the ability of a model to correctly identify the stage is critical. Three winter wheat plant process models were compared as to the accuracy of their estimated stage date predictions for large areas.

The models compared were CERES-wheat, TAMW, and A. M. Feyerherm's modification of the Baier-Robertson model. Each model was used to predict

phenological stage dates for Kansas crop reporting districts (CRD's). The predicted dates were compared to observed dates which were collected by USDA/SRS for use in the agency's *Weekly Weather and Crop Report* for the years 1952 through 1980. The predicted stages included jointing, heading, dough, and ripe. Final yield estimates were also compared.

Results indicate that CERES-wheat is slightly superior in its predictions. The Baier-Robertson model is about 23 days early in predicting jointing. TAMW is consistently about 10 days early on all observed stages. Each of the models would be useful in predicting phenological stage dates and yields accurately, but the CERES-wheat model is recommended for predicting winter wheat growth stages at the CRD level.

A phenology model for soybeans was not available for application, so one was developed. Much is known about the sensitivity of soybean development to meteorological conditions. The soybean plant responds strongly to daylength and temperature in its phasic development. Daylength responses, especially, vary greatly among varieties. Under very dry conditions, water stress may also affect development. Attempts to develop physiologically-based large area yield models for soybeans have been hampered by the lack of a growth stage model which incorporates these responses and is also applicable to a wide range of geographic and climatic settings.

A phenology model was developed and tested for soybean maturity groups I to V. The model is based on temperature, daylength, and water availability. The model coefficients were tested on data taken at the same time at Spickard and Mt. Vernon, Missouri, and on data for the 1981 season from 22 international sites. The test results indicate that the model will generate reliable estimates of

soybean growth stages over a wide range of climatic conditions.

The model is suitable for incorporation into a soybean growth simulation model or for running as an independent crop calendar model. It requires only daily maximum and minimum temperatures and rainfall.

Regression Models

Following the techniques used to develop the Argentina wheat models in FY 1982, additional yield models for Argentina and Brazil were developed during FY 1983. Two models were derived for Argentina's yields of corn and soybeans. These models are at the country level and are based on monthly average temperature and monthly total precipitation at stations in the crop area. The corn and soybean areas, both very similar, are located in a small part of central Argentina's humid Pampas.

Covariance models were derived for Brazil's wheat and corn yields. These models may be used to provide estimates for the states in Brazil. For wheat, five states were included in the model, and for soybeans, seven states were included (fig. 35).

For the past two growing seasons, models have been developed, improved, and operated for production in the three principal USSR grain producing areas (the Ukraine, Kazakh, and Belorussia). Grain models have been developed and preliminary results are being evaluated. These models are of the correlation or regression type, using several years of meteorological data and a published series of production estimates. The models indicate a sensitivity to weather variables as indicated by the changes that occur between using preliminary and final World Meteorological Organization (WMO) data. Model output generated on a current basis has been provided to

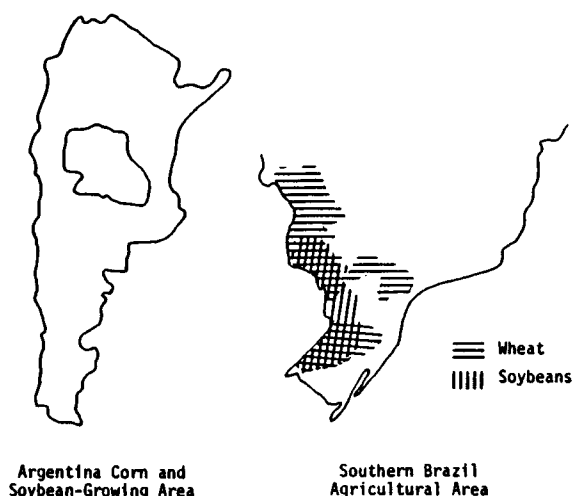


Figure 35.- Regression yield models developed for corn and soybeans in Argentina and for wheat and corn in Brazil.

those in USDA responsible for foreign estimates.

Other Model Evaluation

Sponsored research continued with development of a wheat model that is based on relationships observed from experimental plots, but designed to operate on aggregated data. Evaluation of this model was conducted for spring wheat in Minnesota and North Dakota, and for winter wheat in Indiana, Kansas, Montana, and Ohio. Results indicate that the model, as compared with CEAS or Thompson-type models, may have a higher degree of response to unusual conditions, without the requirement for site specific input data.

4.3.3 Yield Model Research and Development

The USDA/SRS has cooperated with scientists at the University of Florida to

build a plant process model for soybeans, which can be used to predict yields at various stages of plant growth. In fact, the model has much broader application. It is part of a University project to develop models to aid in the farm management decision-making process. The structure of the model consists of leaf, stem (including petioles), shell, seed, and root tissue components.

In the model, the plant components are described as biomass per square meter of ground area. The structure of the model has been developed to describe the rates of change of component biomass resulting from changes in photosynthesis, respiration, tissue synthesis, and senescence processes. The model is interactive and contains menus displaying selected weather, management strategy, insect propagation, and production practice options.

Operation of the model, from a user's point of view, has three phases. In the first phase, the user selects the scenario and strategy. The second phase consists of a simulation of the entire soybean season for the conditions selected. In the third phase, the user selects the variables for graphing and obtains within-season plots of variables such as LAI index, insect population density, seed weight, and percentage of defoliation. Also produced during this phase are season-end results of yield, net profit, pesticide applications, and irrigation applied. The season-end values are provided for comparisons of strategies from run to run, whereas within-season values are displayed for evaluation of model behavior relative to expected or previously observed behavior. The user may then make another run, changing as few or as many menu selections as desired, or he may end the simulation session.

When the model is used for prediction purposes, plant part data collected in sample fields can be fed back into the

model at the appropriate date(s) so that various predetermined parameter values can be modified to provide a description of simulated plant growth which is "closer" to observed plant growth.

Other historical weather data for the general field site or simulated weather with location parameters is used as the weather for the remainder of the growing season to provide stochastic results for yield.

4.3.4 Satellite Spectral Inputs for Crop Yield Models

NOAA-7 Thermal Infrared Evapotranspiration Study

Data were acquired this year to investigate NOAA-7 thermal-infrared sensing related to plant evapotranspiration (ET). Exploratory research was conducted in this area because of the difficulty in obtaining ET information through other means; ET is important in modeling plant processes for yield determination. Input to ground measurement models generally involves a water balance model approach with an initial soil moisture determination and fairly precise "continuous" precipitation measurement over the growing season at or near a point for which the model is to be operated (plot level).

The intended use of the data is to determine if, over a growing season, there is a relationship between daily polar orbiter satellite observations and crop ET as determined by ground measurement input models. The logic for investigation is that canopy air temperature differs from air temperature above the canopy and that the difference is related to ET.

If satellite thermal measurement at resolution level (1 kilometer) has a

sufficiently strong relationship to the evapotranspirative condition over a site, satellite measurements can be used as direct input, or as a supplement to ground measurement input, to plant process simulation models.

The recalibrated model is obtained by minimizing a weighted error function, which is constructed by the user with specific plant part variables and corresponding weights for each data collection date.

Vegetative Information From NOAA-7 Data

A specialized data set providing global coverage from channels 1 and 2 from the NOAA-7 polar orbiter was made operational. Data begin in April 1982 and are available within a week after acquisition. Several products are available from these data for assessing global crop conditions.

Time series of the GMI (GMI = channel 2 - channel 1) for specified areas compare conditions the current year with conditions the previous year.

Maps of channel 1 and channel 2 displayed in the Ambroziak Color Coordinate System (ACCS) indicate areas where vegetation is stressed. The time series of these images, as well as a year-to-year interpretation, were prepared for selected areas of the world.

Progress maps display the condition of vegetative reflectance (GMI) in a season. For example, the advancement of vegetation to the north, which follows the movement of precipitation in North Africa, can be monitored throughout the season (fig. 36). This vegetative reflectance can also be used to compare conditions this year to those last year, or conditions this week to those last week.

ORIGINAL PAGE
COLOR PHOTOGRAPH

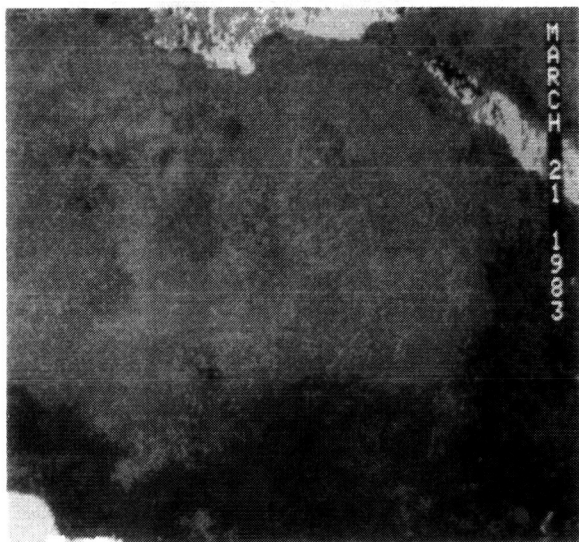
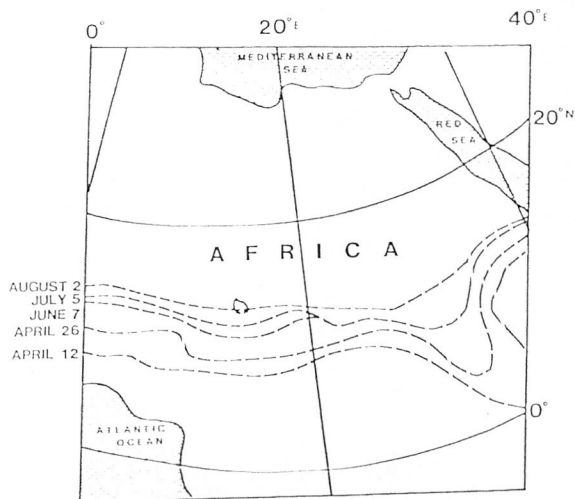


Figure 36.- A vegetation progress map of Northern Africa derived from AVHRR vegetation indices.

The GMI is differenced at each pixel; this difference is then displayed on a map (fig. 37).



Figure 37.- Comparison of changed vegetation conditions between 1982 and 1983 in the Central United States, derived from AVHRR vegetation indices (day 122).

Yield indications based on the GMI are available for areas around the world. This work was started in FY 1982 and was extended geographically to corn in FY 1983. The yield indication was for the 1983 U.S. corn crop (fig. 38). The limiting factor is the requirement for the yield estimates of the previous year.

Efforts in FY 1984 will attempt to improve the quality of the global coverage data for channels 1 and 2.

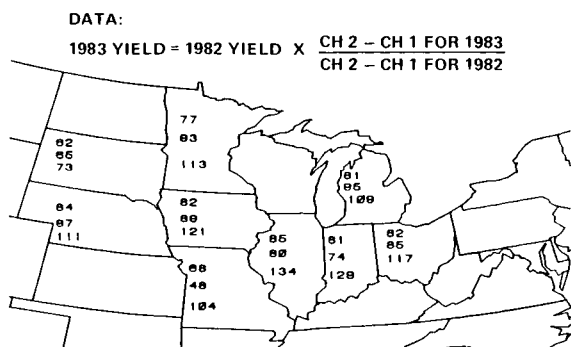


Figure 38.- Predictions of 1983 U.S. corn yields (in bushels per acre) from AVHRR. The upper number represents the 1983 yield as estimated from AVHRR data; the middle number the 1983 yield as estimated by USDA, October 1983; and the lower number the 1982 USDA final yield.

Satellite derived information on vegetative conditions will be evaluated along with information from crop simulations, i.e., plant process models, to determine their joint contribution to assessing crop conditions.

4.3.5 Data Acquisition, Processing, and Storage

Area Specific Reference Handbooks

Agroclimatic information for selected geographic areas was required to support many of the AgRISTARS tasks. Some of these activities include building yield models; developing training sets for satellite assessments; and extending plant process models to new areas. Therefore, handbooks were prepared with divisions in the text for geography, soils and vegetation, climate, and agriculture. Each handbook contains crop calendars for the major crops in all the agricultural regions within the country. Also, maps of the crop-growing areas of the countries are featured. The

handbooks provide a quick and easily understood reference for assessment of the climate/agriculture for these countries. Development of additional handbooks in FY 1985 is planned.

The handbooks currently available are:

- #1 Agroclimatic Handbook - Argentina
- #2 Agroclimatic Handbook - Brazil
- #3 Agroclimatic Handbook - Australia

Daily Meteorological Data for Argentina and Brazil

Historic daily temperature and precipitation data are needed to evaluate the plant process models in Argentina and Brazil. Data were developed during FY 1982 at the National Climatic Data Center. The synoptic reports transmitted on the Global Telecommunication System were used to produce daily estimates of daily maximum and minimum temperature and daily precipitation amounts. These data were incomplete; the plant process models need complete data throughout the growing season as well as prior to that time. This requirement for prior data is necessary to establish the soil moisture. It was necessary to use spatial and temporal objective analysis both for quality control and for providing missing data. The quality control was done in FY 1983; controlled and complete data sets were provided to allow some testing to begin in FY 1984.

Micro-Computer Applications

Several AgRISTARS data sets and tasks are on Apple microcomputers. NOAA-7 data from channels 1 and 2 have been displayed in color on the Apple computer but not in the ACCS. Real-time data can be acquired by dial-up from the U.S. National Weather Service (NWS) IBM 360/195 mainframe computer. Regression models can be developed on

the Apple microcomputers. These models can then be used to provide real-time yield estimates using data retrieved from the NWS real-time data sets. Communication with Apple computers at other locations was also accomplished, and data were successfully transmitted.

Corn/Soybeans Data Base

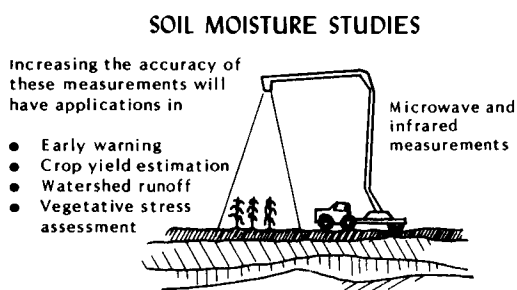
A data base was developed of production input variables and yield performance trials for corn and soybeans in the U.S. Corn Belt region. Progress was also made in developing procedures for

converting soybean performance trials data into a genetic index which will help explain the gradual long-term increase in soybean yield. In addition, a survey was completed for corn and soybean production inputs and cropping practices for sample fields in Illinois, Iowa, and Missouri. This data will be used to help track the effect of changes in cultural practices, input combinations, and technology on corn and soybean yields. Inclusion of these factors as input variables for large area crop yield models will be explored.

4.4 SOIL MOISTURE

The objective of the SM project is to develop and evaluate the technology needed for remote and ground measurements of soil moisture. Development of the technology is an intermediate step in applying the techniques to agricultural information needs. A knowledge of soil moisture is important as input to models for predicting crop yield, plant stress, and watershed runoff. This work will provide knowledge about a key variable needed in several other AgRISTARS projects.

The SM project is managed by the USDA/SCS, working closely with the USDA/ARS and NASA. The scope of the work includes the improvement of in situ soil moisture measurement techniques; the development and evaluation of remote sensing approaches; and through mathematical modeling efforts, relating the in situ and remote sensing measurements to moisture storage over large areas. Applications of the results will be applied to various agricultural and hydrological problems over broad regions.



4.4.1 Technical Objectives

Specific FY 1983 technical objectives included the following:

- Continue basic research on microwave sensor development and evaluation with particular reference to

measurement of dielectric properties and the study of roughness and vegetation effects.

- Conduct an aircraft experiment involving repetitive flights of a dedicated sensor package in order to develop algorithms for estimating surface soil moisture over large areas under diverse conditions.
- Continue to study methods for estimating profile moisture content and ET fluxes from remotely sensed surface measurements.
- Evaluate the use of geographic information systems (GIS's) to support SCS program responsibilities.

4.4.2 Microwave Sensor Development and Evaluation

In order to extract soil moisture information from remotely sensed observations of a vegetation-soil complex, the effects of vegetation on the microwave response must be well understood. A series of vegetation experiments, conducted during the summer of 1982 with truck-mounted microwave radiometers, indicated that certain crops (such as mature corn) have both biomass and structural properties that influence the microwave sensitivity to soil moisture. In particular, the orientation of stalks and the presence of vertical structure in the crop canopy can greatly affect the measured microwave response (fig. 39). The magnitude of this effect varies with the amount of water in the plant, disappearing at low levels of vegetation water content.

Analyses of model simulations and microwave data obtained from truck-mounted radiometers have verified the concept of using time series microwave measurements to distinguish between soil types based on their hydraulic properties (such as ponded infiltration rates, water

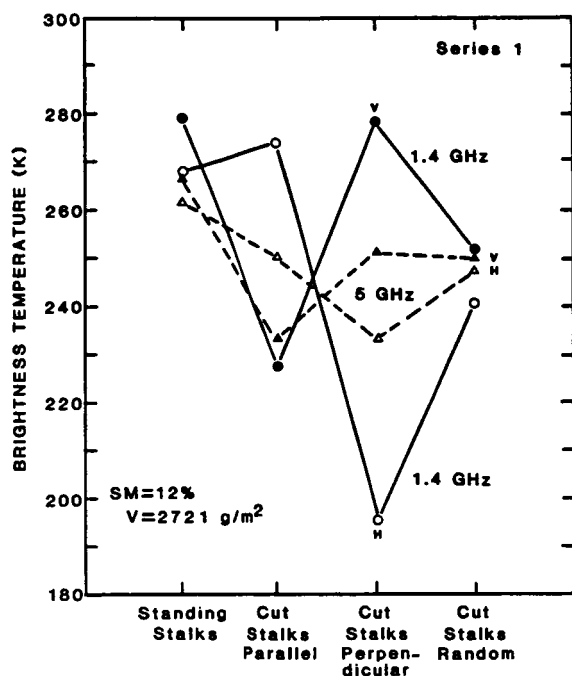


Figure 39.- Effect of corn stalk orientation on measured brightness temperature with vegetation biomass held constant. SM is volumetric soil moisture in the 0- to 5-centimeter layer; V is vegetation water content.

holding capacities, etc.). Results indicate that a relative classification of the hydrologic soil type can be accomplished with a one-time microwave measurement if it is known that the surface soils were subjected to significant rainfall from 1/2 to 2 days prior to measurement. A more quantitative classification can be made if a long-term time series of microwave data can be collected over large areas where some ground verification of soil properties is available.

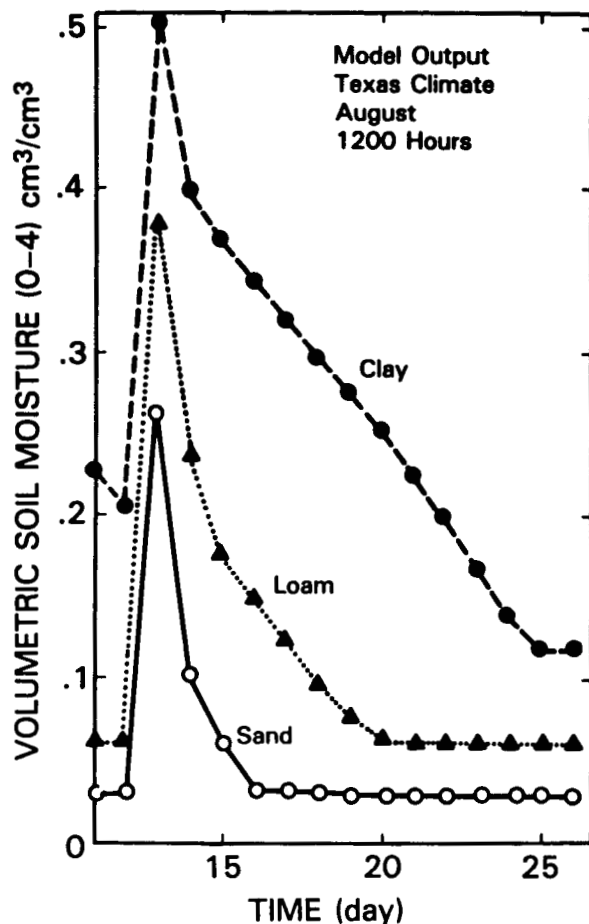
A comparison of the soil moisture response of three 1.4-gigahertz radiometers from truck and aircraft platforms at a variety of test sites indicates that microwave remote sensing of bare soil produces repeatable and quantifiable

results regardless of geographic location and sensor system used. The combined microwave sensitivity of these data sets appears to be on the order of 3.4° K per 1 percent change in volumetric soil moisture for the L-band wavelengths (2.7° K/percent soil moisture if watersheds characterized by some vegetation and surface roughness are included). Detailed examination of data from aircraft flights over agricultural fields in South Dakota suggests that when the data are partitioned according to the level of roughness a direct relationship can be found between the degree of roughness and the microwave response. With the addition of appropriate algorithms to handle the effects of roughness and vegetation, all of these results demonstrate the potential of microwave remote sensing for estimating soil moisture over large areas (fig. 40).

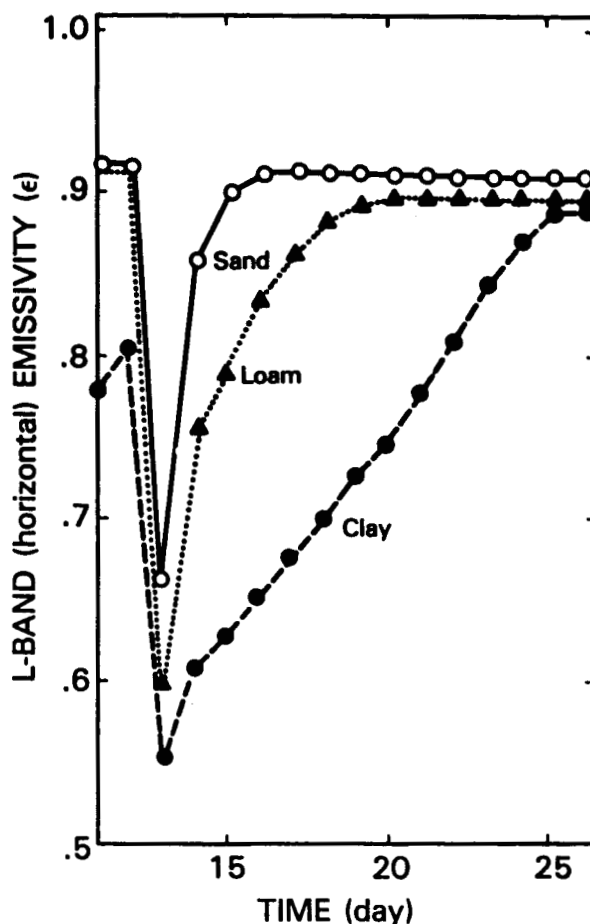
4.4.3 Microwave Radiometer Aircraft Experiments

In late 1982 a series of six microwave data collection flights for measuring soil moisture was made over a small watershed measuring 7.8 square kilometers in southwestern Minnesota. These flights provided 100-percent coverage of the basin at a 400-meter resolution. In addition, three data collection lines were flown at lower elevations to provide a sample of higher-resolution (60-meter) data. The low level flights provide considerably more information on soil moisture variability. General moisture change trends were detectable with the measurements. Surface changes, however, such as crop harvesting and tillage appear to have a major effect on measurements at any one point. Future measurements over a time series will have to account for these changes on the surface.

In 1983 a new aircraft-sensor system was assembled for soil moisture research. This system consists of a



(a) Data from soils physics model.



(b) Data from radiative transfer model.

Figure 40.- Time series microwave emissivity values expected from three different soils during a simulated soil moisture dry-down. Soil moisture profile data from a soils physics model (a) were used as input to a radiative transfer model (b).

three-beam L-band passive microwave radiometer, a thermal-infrared scanner, and an MSS and video camera onboard a NASA Skyvan aircraft.

This system was used in a series of eleven flights between mid-May and late June over sites on the eastern Maryland portion of the Delmarva Peninsula. The

primary purpose of these experiments was to verify system performance. Figure 41 illustrates typical results for a field with a corn crop during this period. Analysis of the results to date indicates that the system is extremely reliable and should require only minimal day-to-day ground-truth verification in large area studies.

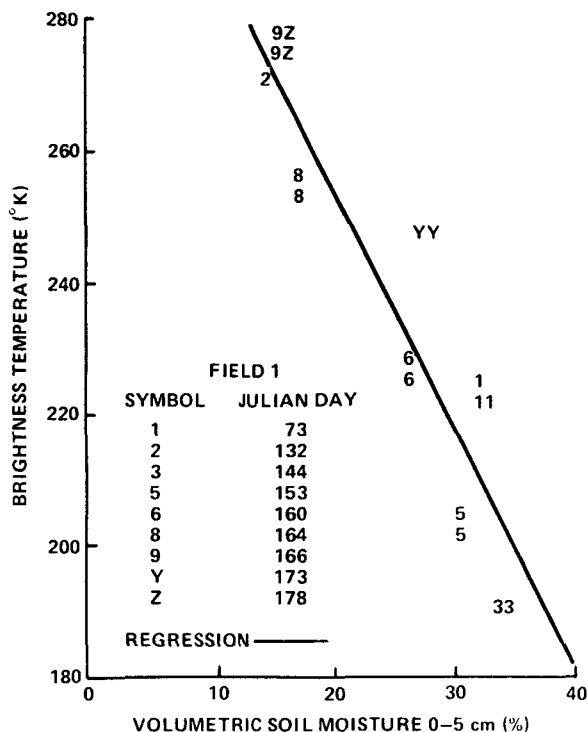


Figure 41.- Maryland cornfield soil moisture versus brightness temperature, 1983.

A second objective of this series of flights was to explore the use of temporal variations in brightness temperature as a source of information on soil moisture and evaporation. Preliminary analyses indicate that cumulative water balance and brightness temperature are highly correlated.

4.4.4 In Situ Sensor Development

A prototype instrument for measuring surface soil water content has been fabricated and is currently undergoing testing and calibration. The instrument uses nuclear magnetic resonance (NMR) techniques to nondestructively and nonintrusively measure volumetric soil

water content at depths of 1.5, 2.0, and 2.5 inches below the soil surface. The instrument is mounted on a small farm tractor and is capable of making continuous measurements at speeds in excess of 10 miles per hour.

4.4.5 Evapotranspiration Studies

Thermal-infrared data acquired by the AVHRR on NOAA satellites were evaluated in conjunction with the visible through the near-infrared reflectances, meteorological data, and land use maps. A quantitative analysis of infrared data for surface energy balance yields reasonable results, consistent with earlier work by a number of authors. In particular, surface evaporation results were consistent with the Penman equation in vegetated areas, while vegetation-free areas had lower evaporation values. Examination of Landsat data and conventional maps of land use shows that the major variability apparent in the NOAA image data, i.e., areas on the order of hundreds of kilometers, is associated with topography, differences in soil characteristics and farming practices, cities and residential areas, and other similar factors.

Inclusion of these factors in the analysis procedure will require a more sophisticated approach involving extraction of map-type data from large-scale, centralized data bases.

4.4.6 Soil Moisture Sensing

The soil moisture sensing program combines theory with laboratory and field experimentation as supported by simulation studies to examine problems with sensor implementation and application.

The dielectric properties of a medium largely determine its microwave scattering and emission characteristics. During FY 1983, several dielectric measurement programs made notable progress.

An ongoing program to measure the dielectric properties of soils as a function of moisture content was expanded to cover the frequency range of 1.4 to 18 gigahertz using free-space and guided-wave transmission techniques. Measurements from a variety of field soils and texturally distinct laboratory soils were fitted with empirical expressions dependent upon frequency, soil texture, and volumetric moisture. In addition, a physically based model, previously found useful at frequencies of 1.4 and 5.0 gigahertz, adequately described the dielectric behavior of moist soil at higher frequencies.

An understanding of the dielectric properties of plant canopy components is fundamental to quantitative description of microwave scattering, emission, and attenuation by vegetation. A variety of canopy components (leaf, stalk, and fruit) was measured by guided-wave transmission techniques to examine the dielectric dependence on plant moisture content. Samples of these data are shown in figure 42 for wheat at 8 gigahertz.

Under field conditions of variable plant geometry and water content, a vegetation canopy both scatters and attenuates incident microwave radiation. Depending upon frequency and angle of incidence, these effects tend to limit a microwave sensor's sensitivity to soil moisture and enhance its sensitivity to canopy properties such as biomass and geometry. A series of field investigations in FY 1983 sought to further our understanding of the influence of crop canopies on scattering and emission. One-way and two-way canopy attenuation experiments were conducted at several points in crop development for wheat (fig. 43), soybeans (fig. 44), and corn. Repeated sampling allows for a description of the statistical distribution of net canopy attenuation for selected

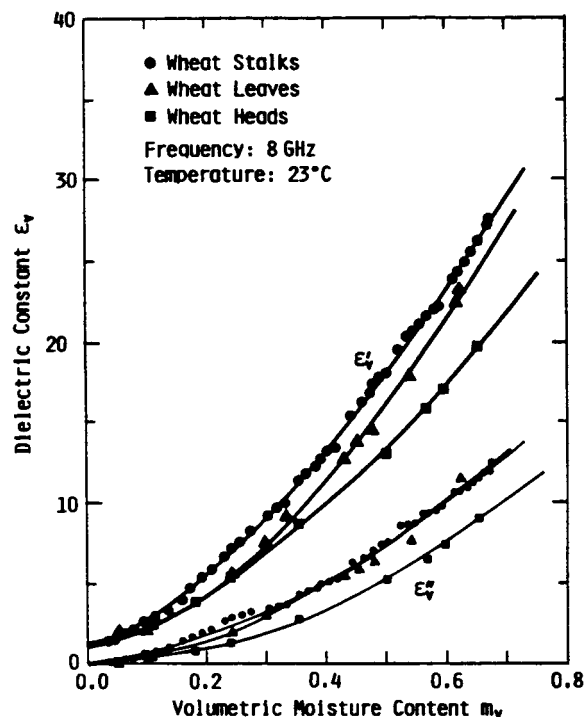


Figure 42.- Dielectric dependence of plant canopy components on plant moisture content.

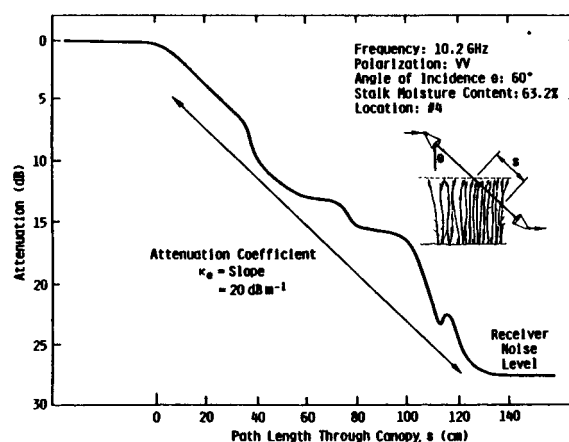


Figure 43.- Microwave measurements of canopy attenuation in crop development for wheat.

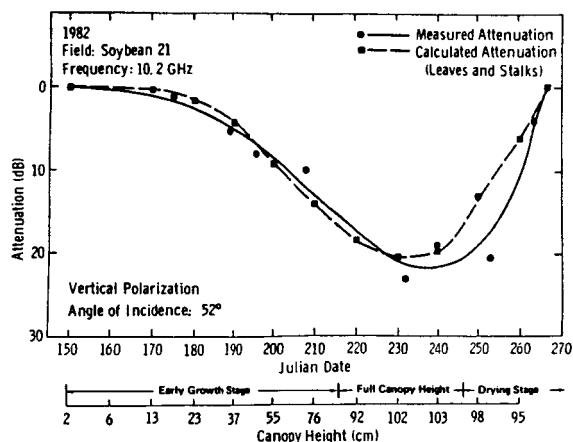


Figure 44.- Microwave measurements of canopy attenuation in crop development for soybeans.

points in crop development (fig. 45) and also permits comparison of canopy attenuation between various crops (fig. 46). Additional experiments sought to quantify the impact on the canopy of free water due to recent precipitation or dew. In figure 47 the presence of free water on mature winter wheat is seen to produce a 3-decibel increase in back-scatter at X-band.

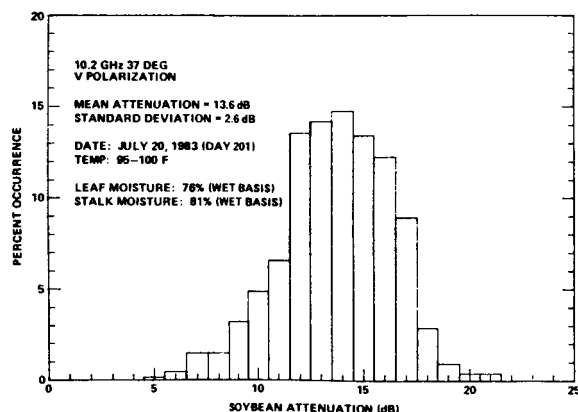


Figure 45.- Net microwave measurements of canopy attenuation for soybeans.

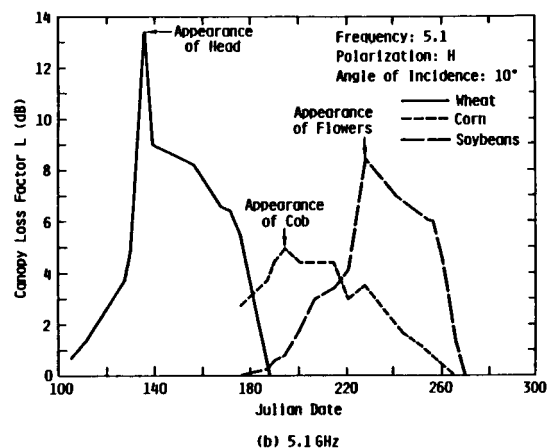
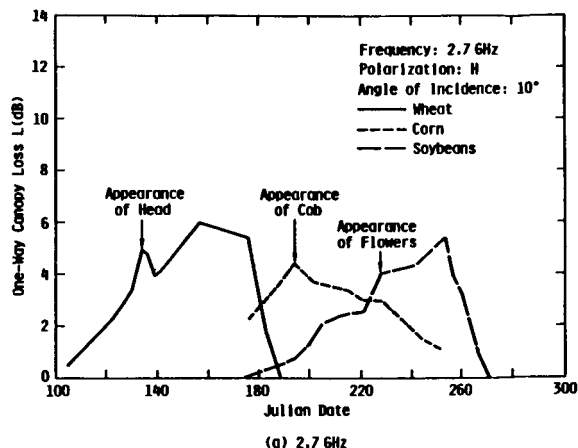


Figure 46.- Comparison of canopy attenuation among various crops.

Since most crop canopies undergo prolonged periods of one or more weeks with relatively constant dielectric and geometric properties (excepting the presence of free water caused by dewfall or precipitation as mentioned above), it may be possible to filter out the local effects of an overlying crop canopy on microwave sensitivity to soil moisture using a change detection approach. Such an approach, successfully applied to L-band Seasat data from southwestern Kansas, showed that orbital imagery can

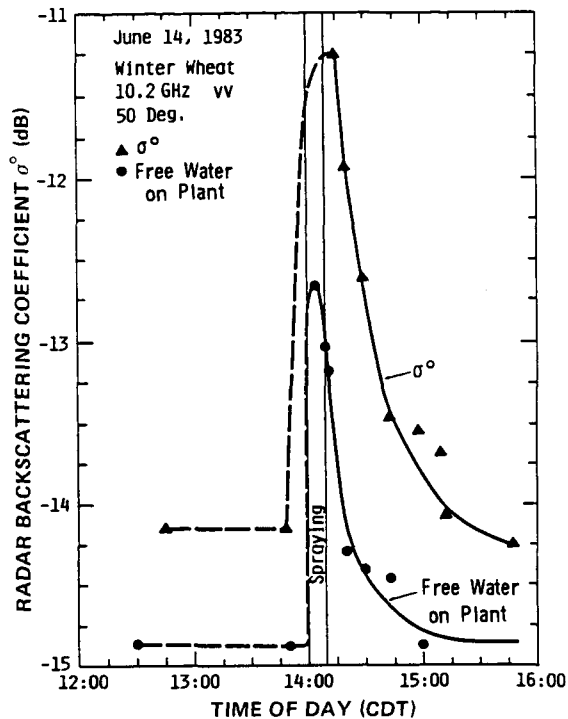


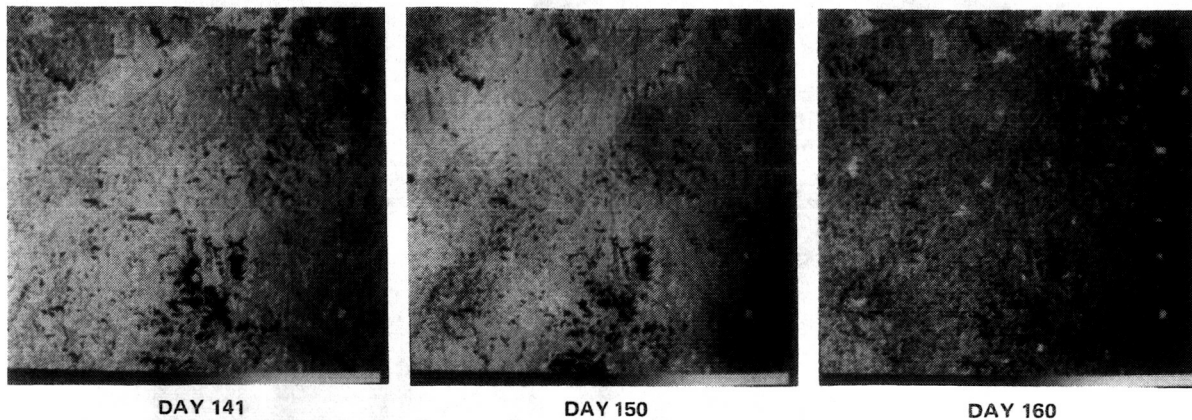
Figure 47.- Effect of free water on X-band backscatter in mature winter wheat.

be readily co-registered, corrected for radiometric offsets, and ratioed to display changes within the scene related to both soil moisture change and crop husbandry practices. During FY 1983, field experiments were conducted for mature canopies of corn and soybeans which were flooded with water and then intensively observed over the following week of evaporative dry-down with both truck-mounted scatterimeters (L, C, and X bands) and radiometers (S and C bands). During this time period the crop canopies remained relatively constant in terms of wet and dry biomass and crop stage growth. The results from this experiment are expected to show the sensitivity of these sensors to near-surface soil moisture in the absence of

complicating effects due to a changing canopy response.

The impact of geographic variables on radar remote sensing of soil moisture from an orbital platform was studied using image simulation techniques. These variables included topography, crop canopy cover, and field-size distribution, as well as the spatial distributions of forests, water bodies, and cultural features. The 1° by 2° USGS Lawrence quadrangle from northeast Kansas served as the test site. A variety of soil moisture distributions was simulated for this 100- by 120-kilometer area, based upon historical precipitation data, soil type, crop type, and crop growth stage. Simulated C-band radar imagery at resolutions of 100 meters, 1 kilometer, and 3 kilometers was used to classify soil moisture within the test site. For subregions within the site, soil moisture classification accuracy at a given sensor resolution was found to be dependent upon the soil moisture level and the local geography of the scene. Figure 48 shows the simulated C-band radar images for three dates with a swathwidth of 120 kilometers corresponding to angles of incidence between 7° and 19°. These dates represent generally moist, wet, and dry conditions for days 141, 150, and 160, respectively. Note the striping on the image for day 141 related to the passage of a storm cell; this is similar to the effects of rainfall noted on L-band orbital imagery obtained by Seasat. Examples of predicted soil moisture distributions for this day are shown in figure 49 at each sensor resolution along with the actual soil moisture distribution. The effect of geographic subregion on moisture classification accuracy is shown in figure 50. This study also found that the use of a change-detection approach yielded about a 10-percent improvement in correct classification of near-surface soil moisture.

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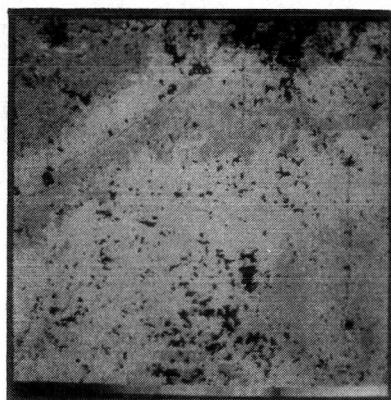


DAY 141

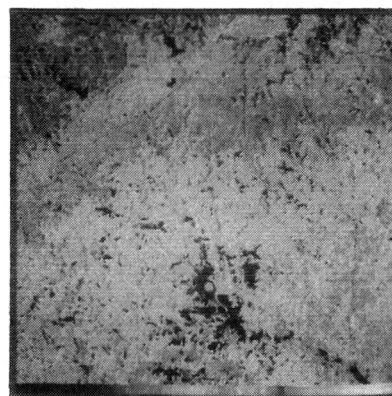
DAY 150

DAY 160

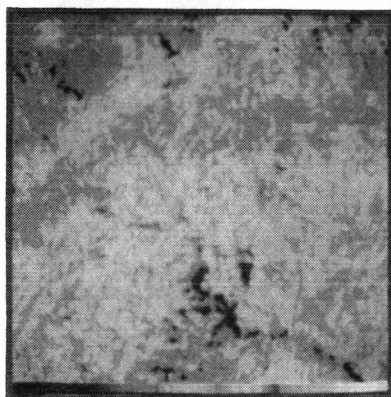
Figure 48.- Simulated C-band orbital radar imagery.



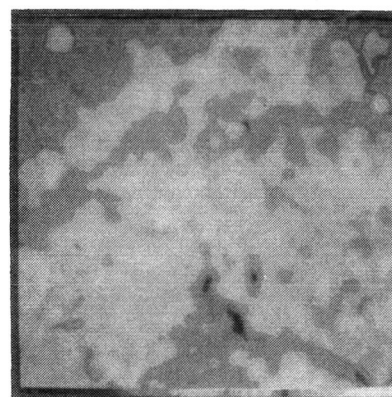
ACTUAL MOISTURE
(100 m RESOLUTION)



PREDICTED MOISTURE
(100 m RESOLUTION)



PREDICTED MOISTURE
(1 km RESOLUTION)



PREDICTED MOISTURE
(3 km RESOLUTION)

Figure 49.- Actual and predicted soil moisture distribution for day 141.

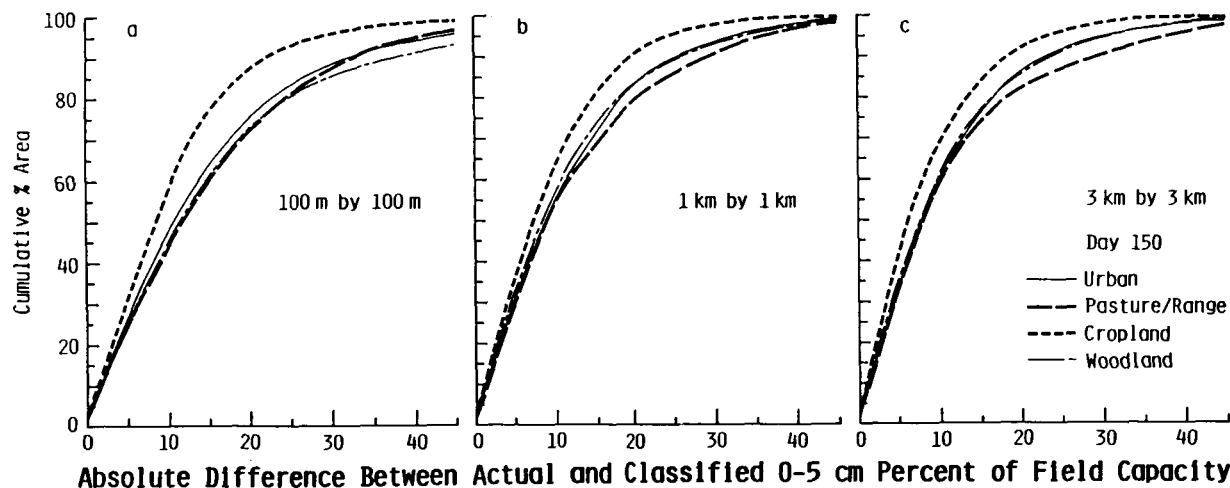


Figure 50.- Effects of geographic size on moisture classification accuracy.

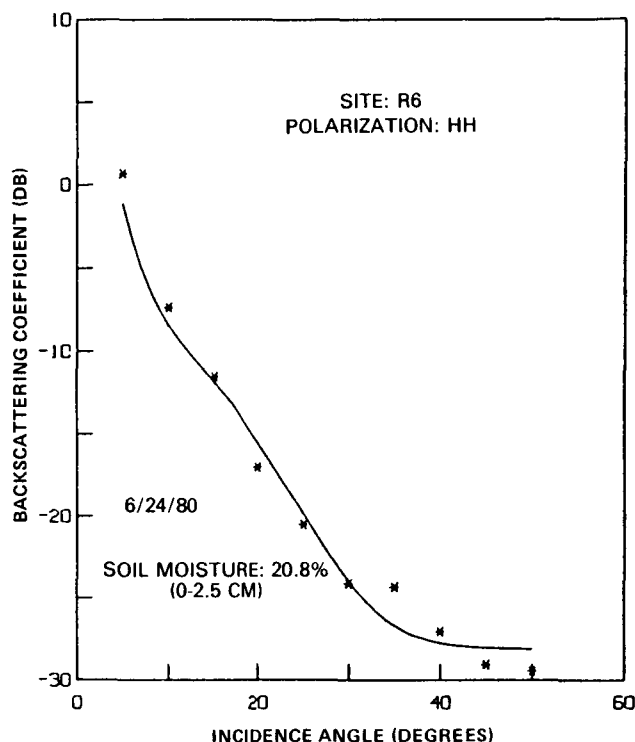
4.4.7 Model Research

In related modeling research, investigators have developed an electromagnetic wave scattering model to simulate the measured angular distribution of radar backscatter from vegetation-covered soil surfaces using a least-squares fit method. The model takes into consideration coherent and incoherent scattering from a rough soil surface, which is characterized by two parameters, the surface height standard deviation and the surface correlation length. The effects of vegetation canopy scattering and attenuation are also included in the model. The model results agree well with data obtained at both L-band (1.6 gigahertz) and C-band (4.75 gigahertz) frequencies (fig. 51). Inversion of model fits to a large collection of scatterometer data can provide reliable estimates of the surface roughness characteristics, particularly the standard deviation of surface height variations.

To describe the thermal microwave emission from a vegetation canopy, the vegetation can be modeled as a homogeneous medium containing discrete

scatterers specified by their size, permittivity, and fractional volume. The discrete scatterers in this case consist of cylinders oriented vertically that model the stalks of vegetation and are specified by their radius and length, and ellipsoidal scatterers of a specified size that represent the leaves of the vegetation. A probability density function specifies the orientation of the ellipsoids. The purpose of developing this model was to quantify the effects of the vegetation canopy on thermal microwave emission from a soil volume. Simulations utilizing this model were compared to experimental measurements acquired over sorghum fields at Texas A&M University. The model simulation compared extremely well with the experimental measurements. The overall results show that the cylindrical scatterers or the stalks of the vegetation have the dominant effect on the thermal microwave emissions from the vegetation volume. Using somewhat different modeling approaches, researchers at Massachusetts Institute of Technology and George Washington University are also making progress toward describing microwave interactions within a crop canopy.

OKLAHOMA: L-BAND DATA AND BEST-FIT RESULTS
 $k\sigma = 0.10$ $k\ell = 4.15$ $\eta = 0.0017$ AND $\tau = 0.06$



OKLAHOMA: C-BAND DATA AND BEST-FIT RESULTS
 $k\sigma = 0.26$ $k\ell = 4.92$ $\eta = 0.0271$ AND $\tau = 0.12$

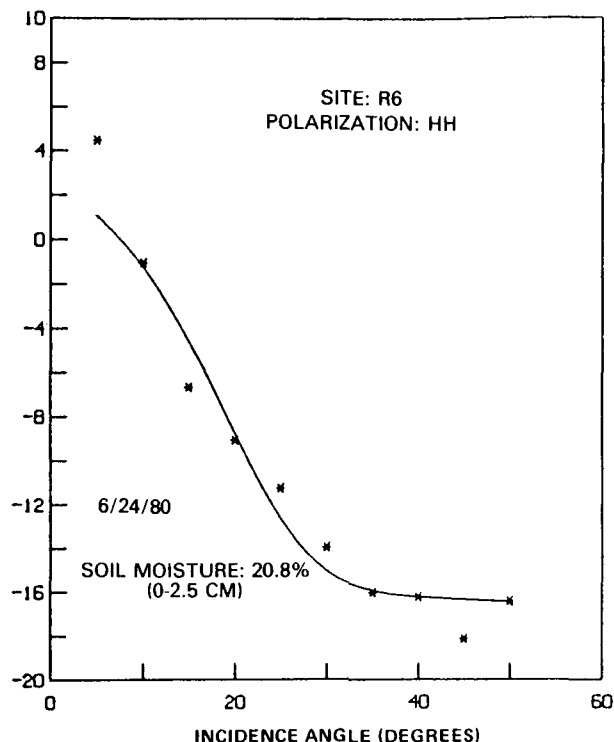


Figure 51.— Comparison of model calculations and scatterometer data for a grassland watershed in Oklahoma.

Theoretical modeling can help to improve our understanding of the fundamental physical processes at work within a vegetation-soil complex. Canopy temperature represents the integrated response of a crop to prevailing weather and soil water conditions. If changes in canopy temperature due to weather can be quantified and accounted for, then it should be possible to infer the soil water status from the canopy temperature. A steady-state model of transpiration has been developed which solves the water balance equation for a plant by explicit accounting of plant physiologic control of water loss from leaf stomata. Once transpiration is known, the canopy temperature is obtained from the energy balance equation. For well-watered corn, soybean, and sunflower crops, the

canopy temperature during the significant portion of the daylight period is determined largely by air and dewpoint temperatures; wind speed and solar radiation have very little effect on the canopy temperature. As root-zone soil water decreases, the canopy temperature increases; this increase is predictable in terms of crop physiology and soil water potential.

A model of the energy and moisture fluxes in the soil and atmospheric boundary layer has been applied successfully to estimate daily evaporation over wheat and barley fields in Germany using thermal-infrared remotely sensed data. A sensitivity analysis of the model showed that for bare soil net radiation was the most important independent

variable required, while for wheat and barley the air temperature and vapor pressure were as important as the net radiation. Thus, ground data requirements do not appear to be excessive when used with remotely sensed data to calculate evaporation with the physically based model. Overall, surface temperature was the most critical remotely sensed parameter, although soil moisture could be an important model input under nonpotential evaporation conditions.

Assuming the capability of remote sensing to measure the net surface soil moisture fluxes, a model was developed to monitor net rainfall and evaporation as well as soil water content over the entire profile for bare soil conditions. Verification of the model simulations with measured field data produced good results.

The ability of a water uptake model for sorghum to predict root zone water content and canopy temperatures was examined with a view toward potential application in remote sensing determination of canopy water stress and crop yield reduction. Total ET simulated over a 50-day period using the model was found to be in good agreement with the experimental values. Soil water content profiles calculated with the model showed some systematic deviation from the measured values, possibly because the physical nature of the profile was assumed to be homogeneous. The spread of the simulated results, however, reflects the variation of hydraulic soil properties. A sensitivity analysis showed minor sensitivity to rooting depth and distribution, and moderate sensitivity to the excretion of water by the roots into dry soil layers.

4.4.8 Geographic Information System

In cooperation with USDA/SCS, NASA Ames Research Center conducted several studies in the uses of GIS's for

support of SCS program responsibilities, including the application of remote sensing technology.

Interagency planning led to the definition of multiple task areas:

- GIS Implementation
- Land Resources Modeling
- Direct Assistance/Remote Sensing

The approach used to study GIS Implementation was to develop analysis scenarios of SCS operational requirements and to relate these scenarios to a comprehensive review of GIS capabilities. A representative set of SCS programs was selected and reviewed, noting the organizational setting of each program and current technology implemented. The individual programs were then translated into the GIS domain and examined for implications to an overall SCS system design. The program translation was simplified by first compiling and documenting generic GIS functional capabilities, and then describing how these capabilities would be implemented within existing SCS programs.

This application of GIS technology to existing SCS programs could be implemented in several ways, including internal SCS implementation, cooperation with state-operated GIS's, and use of Federal data bases. Although the main thrust of the research concerned studies examining the internal implementation of GIS technology, the latter two options were also examined. Through separate studies of existing state and Federal data bases, an inventory was completed, identifying hardware and software in use as well as data types and formats found within each data base. This inventory not only identified potential data sources for SCS, but also provided an insight into GIS implementation.

The internal implementation study was completed by reviewing eight candidate GIS software packages available commercially. The packages were compared to existing SCS processing requirements and the list of generic GIS functional capabilities. An inventory of hardware (including peripherals) capable of supporting the candidate systems was also completed in support of the implementation study. This resulted in a potential system design that would function agency-wide.

For the Land Resources Modeling task, a test was developed to determine the usefulness of an existing data base to address SCS resource issues. The universal soil loss equation (USLE) was implemented and models run to determine severity of erosion problems in Santa Cruz County, California. Results of this test have shown that an existing data base can be used as an automated soil loss information system and that large areas can be inventoried for predicted soil loss with savings in both time and money over conventional ground sampling methodologies.

As part of the Direct Assistance/Remote Sensing task, a study was initiated to evaluate the near-term opportunities remote sensing offers to USDA/SCS. Research was initiated to evaluate remote sensing within the context of the National Resource Inventory (NRI) currently underway within the SCS. An analysis of change detection techniques using Landsat data was completed in Santa Cruz County, California, identifying those techniques valuable in supporting the SCS's national inventory. Results of this study have shown that remotely sensed change detection techniques, when properly applied, can: (1) greatly improve the ability to update and optimize the sampling design of the NRI; (2) provide a "quick-look" data layer to help the resource manager characterize sample plots before field reconnaissance; and (3) reduce field costs by intensively ground checking only those areas identified by remote sensing techniques as having changed through time.

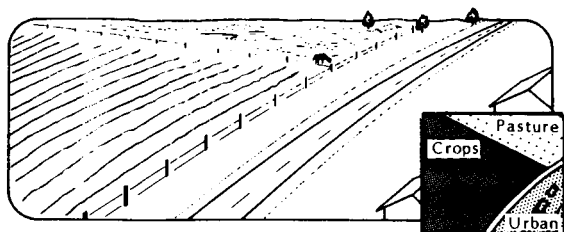
4.5 DOMESTIC CROPS AND LAND COVER

The DC/LC crop acreage objectives are to improve state and substate crop acreage estimates by integrating Landsat data with ground data from the existing USDA program and to evaluate the effectiveness of alternative procedures. The land cover objectives are to explore methods for meeting USDA needs for land cover inventories, land-use change estimates, and mapping products of land cover.

This project is managed by the USDA/SRS with support from NASA. Major crop estimates in the United States are being addressed first in the U.S. Great Plains for wheat and in the Corn Belt for corn and soybeans.

DOMESTIC CROPS AND LAND COVER

Directed at automatic classification and estimation of land cover with emphasis on major crops, this project uses Landsat and advanced sensor data to improve accuracy of data classification on the local level.



4.5.1 Technical Objectives

Technical objectives during FY 1983 focused on the following:

- Developing, testing, and evaluating operational procedures for estimating the acreages of major crops over large areas, such as a state, in a timely fashion.
- Continuing studies to evaluate SRS methodology for estimating land use/land cover.

- Cooperating with various research and government organizations in California for purposes of developing remote sensing procedures applicable to both agricultural surveys and irrigation inventories.
- Evaluating Landsat TM data for their ability to distinguish crop and land cover classes.
- Continuing data processing enhancements.

4.5.2 Timely Crop Acreage Estimation Over Large Areas

For the 1983 crop year, acreage estimates of major crops for seven states were calculated by combining Landsat-4 MSS data with ground data. The seven states were Arkansas, Colorado, Illinois, Iowa, Kansas, Missouri, and Oklahoma (fig. 52). Crops included were winter wheat, corn, soybeans, rice, and cotton. The ground data consisted of information on crop field locations and acreages obtained from the USDA/SRS June Enumerative Survey (JES). The estimates that used both Landsat and JES data averaged about twice as efficient as those based on the JES data alone. SRS has reduced the project cost per state associated with using Landsat data from \$305,000 in 1978 to \$120,000 in 1983.

4.5.3 Land Use/Land Cover Estimation

During FY 1983 a state-level land cover study was conducted in Missouri in addition to the production of timely estimates of crop acreages. For the land cover study, additional items were added to the JES questionnaire used in Missouri. These additional items recorded acreages for 21 nonagricultural ground covers.

Available spring Landsat data were combined with ground data to produce timely crop-acreage estimates for

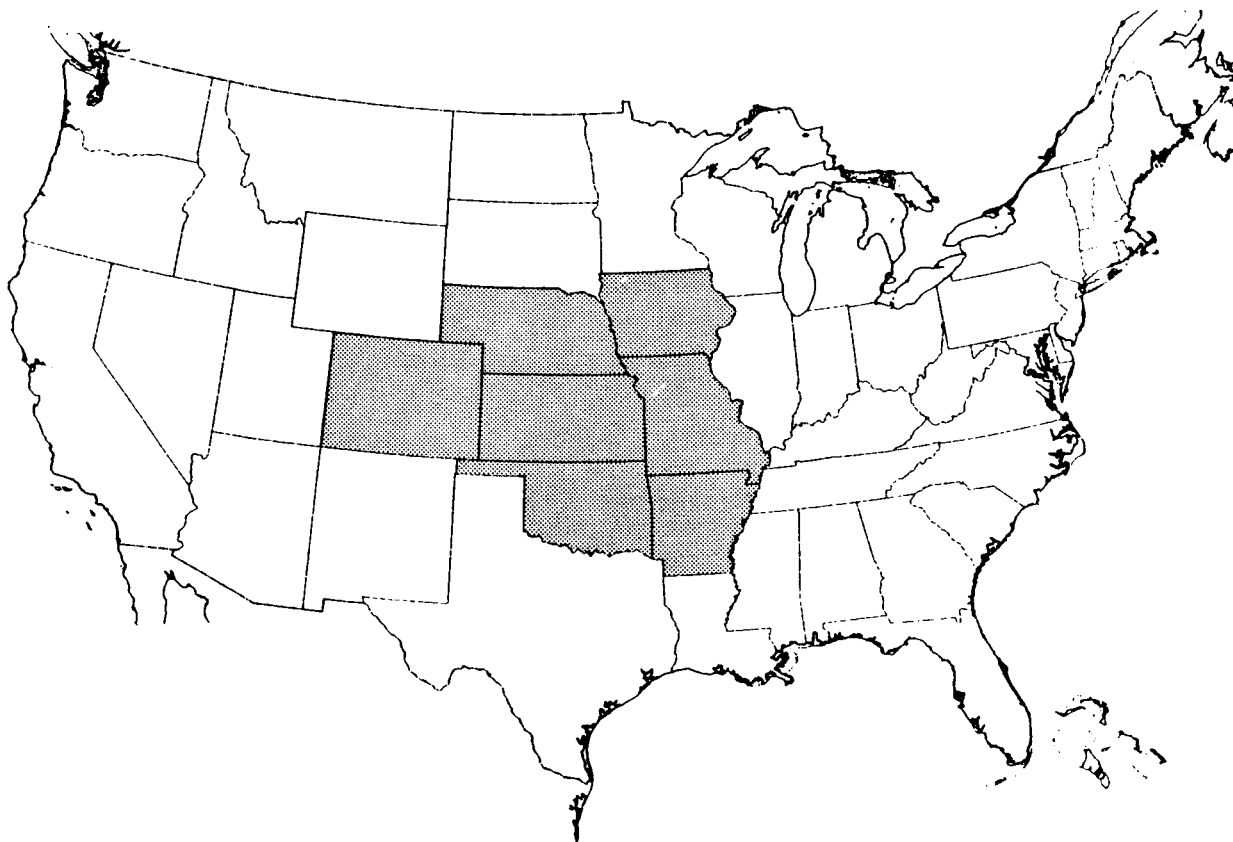


Figure 52.- Seven-state area for which MSS and ground data were combined to produce crop acreage estimates for the 1983 crop year.

planted and harvested winter wheat. Spring-plus-summer Landsat data were combined with ground data to produce estimates for cotton, rice, corn, and soybeans. In early 1984, the classification of the spring-plus-summer Landsat data will be used to calculate state-level estimates for the 21 nonagricultural ground covers.

Also in FY 1983 a study was completed that analyzed the results of using single-date versus multirate Landsat MSS data, plus the results of

stratifying by soils. This study was conducted in Robeson County, North Carolina, for the land covers of forest, soybeans, corn, and tobacco. The study findings were that the stratified, multi-temporal procedure had the highest overall accuracy. The addition of a June Landsat MSS data set to an August data set had about the same effect on overall classification accuracy as the stratification of the August data set by soils. However, the unstratified, multirate approach was clearly better for crop discrimination.

4.5.4 California Cooperative Project

Research on remote sensing for application to irrigated agriculture was initiated in California in FY 1982. This work continued in 1983. In addition to SRS and NASA, cooperators in the project included the California Departments of Agriculture and Water Resources and the University of California at Berkeley. This project was designed to develop remote sensing procedures applicable to both agricultural surveys and irrigation inventories.

California has a large number of minor crops rather than a small number of major crops. This distinguishes it from Midwestern states, where most of the DC/LC work in crop-acreage estimation has been performed. The applicability of the DC/LC crop-acreage estimation procedure (described in section 4.5.2) to California was studied in FY 1983. The study findings show that with minor modifications the DC/LC procedure is applicable to California agriculture.

The FY 1983 study also produced county estimates of crop acreages and produced resource maps based on calculated values called crop odds. A crop odd is the probability that a Landsat pixel is a particular crop. Figure 53 illustrates a map based on crop odds.

4.5.5 Landsat TM Evaluation

In FY 1983, classification accuracies were compared for Landsat MSS and TM data simultaneously acquired over the Albemarle Sound region of North Carolina. This comparison assessed the effects of sensor attributes that differ between the two sensors, i.e., spectral, spatial, and radiometric resolutions.

Three data sets were computer classified: six- and three-band TM data sets and a three-band MSS data set. The study concluded that the improved

classification accuracy for TM data resulted primarily from improved radiometric resolution and additional spectral bands. The increased spatial resolution of TM data played only a minor role in increasing classification accuracy because of the large fields in the study area.

4.5.6 Data Processing Enhancements

In late FY 1982, NASA Ames Research Center replaced their ILLIAC IV computer with a Cray 1S computer. Several processing steps in the DC/LC crop-acreage estimation procedure were programmed on the Cray 1S during FY 1983. The cost of classifying an entire MSS scene (four channels) into twelve categories was reduced from over \$1000 on the ILLIAC IV to \$35 on the Cray 1S.

Processing steps not performed on the Cray 1S are performed on a commercially time-shared DEC-10 computer. In FY 1983, work was initiated to rewrite the computer programs for these processing steps. The rewritten programs will be able to execute on a microcomputer-based system or on mainframe computers other than the DEC-10.

One of the processing steps of the DC/LC crop-acreage estimation work is the digitization of ground-data photographs. Prior to FY 1983 this was done with a digitizing tablet connected by telephone line to the DEC-10. In FY 1983 two alternative digitizing procedures were evaluated. In four states a digitizing tablet connected locally to a microcomputer was used. This resulted in considerable savings in telecommunication costs. The ground data for three other states were digitized with video digitizing equipment located in Washington, D.C. Consisting of a television camera, an image processing system, and a minicomputer, this equipment makes possible high throughput digitizing of ground data.



SMALL GRAINS	PERMANENT PLANTINGS	▤▤▤▤▤▤▤▤
OTHER CROPS :::::::::::	PASTURE	▧▧▧▧▧▧▧▧
RICE ○○○○○○○○	NON-AGRICULTURAL LAND	■ ■ ■ ■ ■
HAY ▨▨▨▨▨▨▨▨		

Figure 53.- Comparison of USGS topographic map and crop-odds map. The mapped area is a portion of the USGS Tisdale Weir quadrangle in California. In the shaded portions of the crop-odds map, the indicated crop odd exceeds 0.75. In the unshaded areas, all crop odds are less than 0.75.

4.6 RENEWABLE RESOURCES INVENTORY

The objectives of the RRI project are the development and implementation, in the USDA Forest Service, of new remote sensing technology which will offer capabilities in support of the national renewable resource assessment process. The USDA Forest Service is the management agency in the RRI project, and will be the user of the technologies developed.

Four main categories are being addressed:

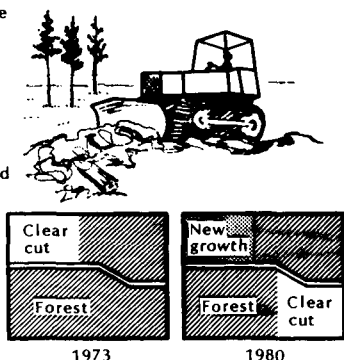
- National Inventory
- Stress/Damage Assessment
- Timberland Classification
- Environmental/Land Use

RENEWABLE RESOURCES INVENTORY

Four main categories are being addressed:

- (1) National inventory
- (2) Stress/damage assessment
- (3) Timberland classification
- (4) Environmental/land use

Use of data from the Landsat multispectral scanner and the more detailed data from the improved sensors is planned.



Use of data from the Landsat MSS and the more detailed data from the improved sensors is planned.

4.6.1 Technical Objectives

The particular objectives in FY 1983 were focused on:

- Improving methods for collection, display, and use of resource information for more efficient forest management.
- Completion of the Multiresource Inventory Methods Pilot Test (MIMPT) and publication of the final report.
- Transfer of remote sensing technology to field users.

4.6.2 Forest Management and Remote Sensing Activity

Sixteen missions were flown using the NASA U-2 aircraft with advanced camera systems to obtain resource data to support developmental projects. The San Juan National Forest, Colorado, continues to be a prime area for the testing and evaluation of remote sensing techniques. Other areas of data acquisition include the Hill Country in central Texas, east Texas Pineywoods, and the Northeastern United States. The Texas data were used to evaluate the extent of infestation of oak wilt in central Texas and the extent of the southern pine beetle outbreak in east Texas. The data acquired over the Northeastern United States were used to determine the extent of hardwood defoliation caused by the gypsy moth. Improvements were made on equipment used to laminate positive transparency film. Lightweight portable light tables were designed, constructed, and tested for use with positive transparency film. Testing was done on part of the 1983 demonstration of optical bar panoramic aerial mapping of hardwood defoliation (caused by the gypsy moth) over a multistate area of the Northeastern United States.

4.6.3 Multiresource Inventory Methods Pilot Test

The MIM PT was concluded and a final report was written. The MIM PT demonstrated the potential use of Landsat satellite technology for conducting recurrent inventories over large land areas. Driven by USDA Forest Service requirements, the pilot test provided information to support resource planning activities as well as forest inventory and assessment activities at national, state, and multicounty levels.

4.6.4 Technology Transfer

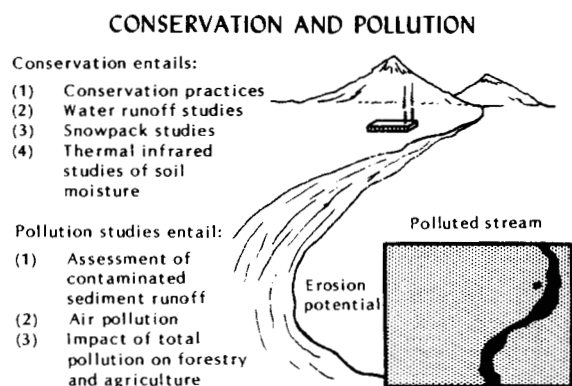
Considerable emphasis was placed on transferring remote sensing techniques to the field users in the Forest Service as well as to other state and Federal agencies. Several advanced remote sensing and photointerpretation workshops were conducted at the field office level. Support was provided to several field units to carry out local remote sensing projects.

4.7 CONSERVATION AND POLLUTION

The conservation assessment portion of the C/P project addresses applications in three areas: inventory of conservation practices, estimation of water runoff using hydrologic models, and determination of the physical characteristics of snowpacks.

The pollution portion of the C/P project provides an assessment of conservation practices through the use of remote sensing techniques to assess quantitatively such factors as sediment runoff, gaseous and particulate air pollutants, and the impacts of these factors on agricultural and forestry resources.

The USDA/ARS manages the C/P project with support from NASA and NOAA.



4.7.1 Technical Objectives

Specific FY 1983 technical objectives focused on the following:

- Determining the utility of remotely sensed data for the identification and inventory of existing soil conservation practices and for input to erosion models.

- Determining the suitability of present and planned remote sensing data for use in existing hydrologic models and developing new models or components to incorporate remotely sensed data for water resources management.
- Using available visible, near-infrared, and microwave satellite data in conjunction with radiometric measurements from ground-based and aircraft systems to analyze the physical properties of snow and the effects of changes in snowpack conditions.
- Studying the potential use of Landsat MSS data as input to pollution models and evaluating methods of remotely measuring atmospheric oxidants in areas where impact on vegetation is suspected.

4.7.2 Conservation Practices Inventory

Preliminary data analysis during FY 1983 indicated that some conservation practices can be successfully detected in Landsat-4 TM data. However, a number of existing practices are of such size and definition that present sensors and standard techniques cannot detect them with great accuracy.

High-resolution photography at two different scales has been evaluated for the Kansas, Mississippi, and Oklahoma test sites. A matrix has been developed from the results of that interpretation which indicates the requirements for identifying a number of different practices.

4.7.3 Soil Erosion Modeling

The goal of this task is to survey the feasibility of using remote sensing techniques for providing various inputs to an erosion model using the USLE. Four areas experiencing large soil loss rates have been chosen as study sites in Alabama, Kansas, Mississippi, and

Oklahoma. Remotely sensed data from the Landsat MSS and the TM are being integrated with digitized soils and topographic data bases as input for determining the values of the various factors that make up the USLE.

All remotely sensed data have been acquired, and construction of digitized soils and topographic data bases has been completed in FY 1983.

Preliminary use of the USLE model with Landsat MSS data in Alabama and Mississippi has been reviewed with the USDA/SCS personnel of these states, and results indicate great promise.

4.7.4 Water Resources Management

The SRM has been tested on a variety of basins worldwide, with tests recently completed on the largest basin studied so far, the Kings River Basin (4000 square kilometers) in California. Results from the model applications consistently indicate that satellite snow-cover extent is the most important variable for SRM. Figure 54 shows the results from 4 years of simulations of runoff using SRM throughout the snowmelt-runoff season, with snow-cover extent information being obtained from both NOAA and Landsat. Results from 14 international basins indicate that the model accuracy for simulation of seasonal water yield (volume) is 97 percent and of daily flows is 85 percent. The SRM User Manual has been published (NASA RP-1100), and SRM is ready for conversion to operational forecasting.

The U.S. NWS River Forecasting System (NWSRFS) model is being modified to accept remote sensing data. One aspect of the modification involves restructuring of procedures in the model to permit remote sensing updates of model states and forecasts. The other important aspect is the development of a method to areally average data acquired over a

basin by both conventional and remote sensing means for input to models. Such a method has been developed and is called the correlation area method (CAM). This method takes into account that there are certain basic differences in spatial and temporal coverage of various types of data. The CAM can apportion and weight conventional point data, aircraft flight line data, and spaceborne large-area coverage observations over the same basin. Different combinations of data will be available at different times, and CAM will allow basin-wide parameter estimates based only on the data available at a given time. Thus, data emission from certain sensors at any time will not prevent operation of the model.

A more long-range approach to utilizing this new technology is to design a family of hydrologic models to be compatible with remote sensing capabilities. The overall framework (fig. 55) for this model has been assembled. The model is designed to use: general hydrologic land cover categories available from satellites; snow-covered area for driving a snowmelt-runoff algorithm; surface soil moisture available from microwave data for soil moisture accounting and linkage to a soil moisture profile model; vegetative indices, biomass estimates, and surface temperature for ET and interception calculations; and high-resolution data for channel network and overland flow considerations. In addition to making optimum use of the spatial and temporal characteristics of the remote sensing data, the new model employs a GIS as an integral feature for overlaying data, merging data of different characteristics, and performing hypothetical basin treatments for design studies. The digital format of the remote sensing data and the large volume of data that can be collected with remote sensing make the use of the GIS mandatory. The new model is now ready for field testing.

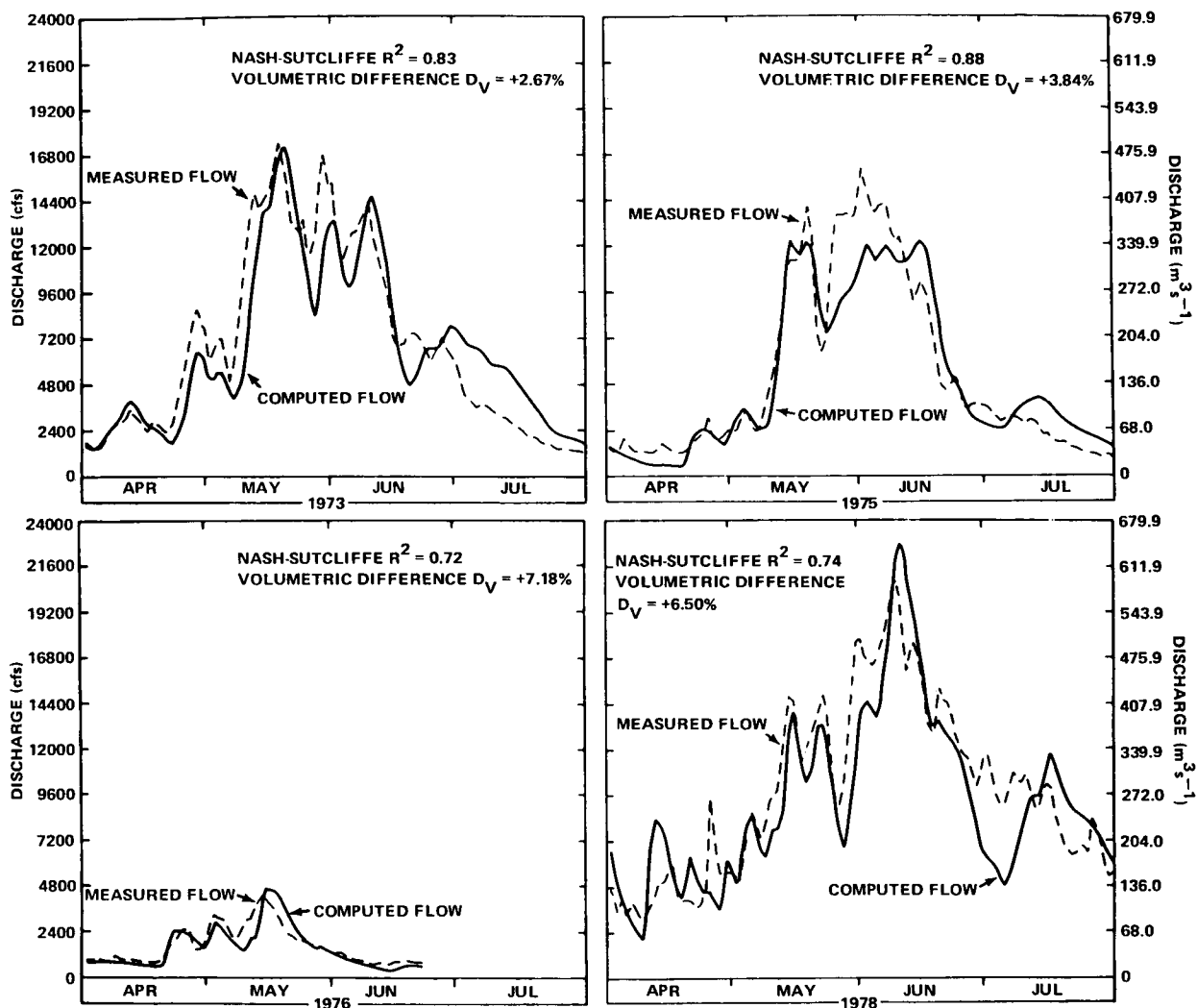


Figure 54.- Discharge simulation for the Kings River Basin, California, using the snowmelt-runoff model.

4.7.5 Snowpack Studies

A field and aircraft experiment was conducted in the Sierra Nevadas in California in February 1983. Snow pit data were collected by investigators from the University of California at Santa Barbara during an overflight by a NASA CV-990 aircraft equipped with the airborne multichannel microwave radiometer (AMMR). The objective of

this experiment was to determine the microwave signatures of deep (less than 2 meters) snow. Data are under analysis.

Using scanning multichannel microwave radiometer (SMMR) satellite data, investigators found that a comparison of the horizontal and vertical polarizations can be useful for analyzing the structure of a snowpack. Analysis of data from 10 satellite overpasses of the Midwestern

STRUCTURE OF REMOTE SENSING BASED CONTINUOUS STREAMFLOW MODEL CURRENTLY UNDER DEVELOPMENT

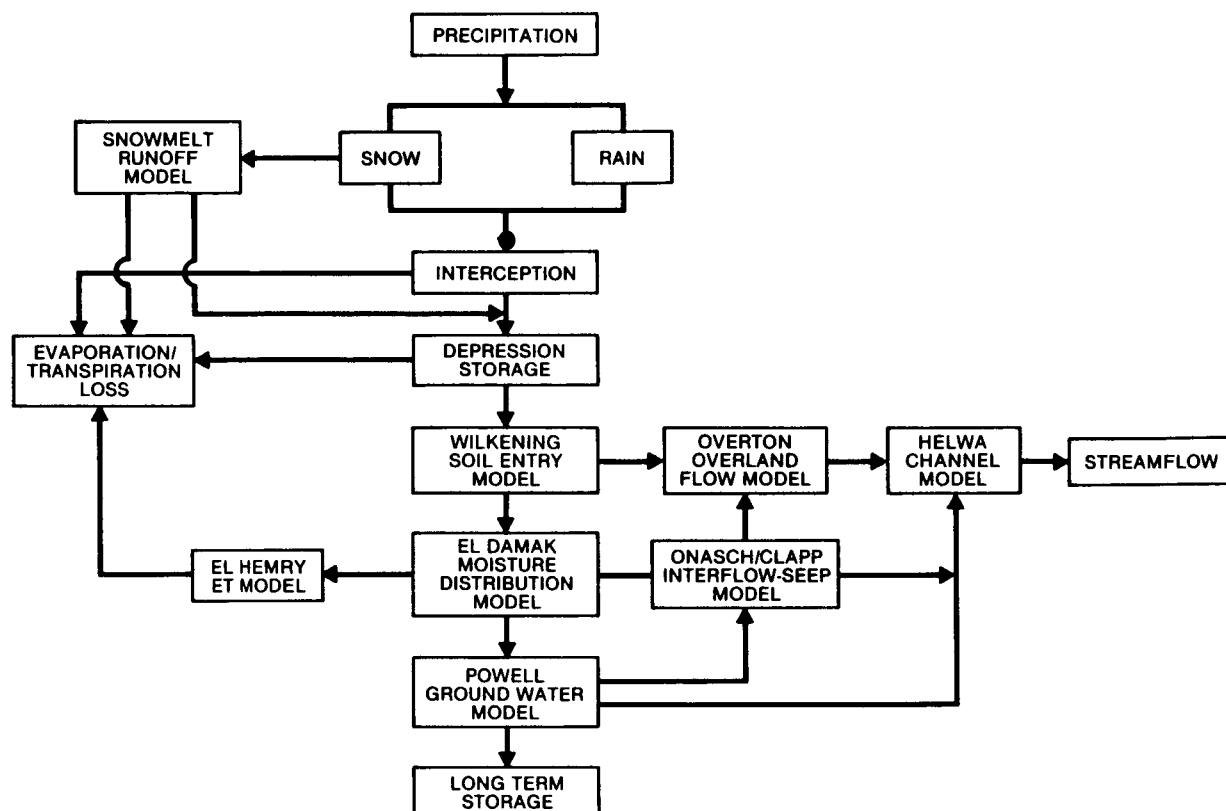


Figure 55.- Structure of remote-sensing-based continuous streamflow model currently under development.

United States has revealed that horizontally polarized T_B (radiation temperature) data correlate better, in general, with snow depth than do vertically polarized data. In addition, when large discrepancies were found in the response of the horizontally and vertically polarized data to snow depth (fig. 56), snowpack melting and/or metamorphism was apparently occurring.

4.7.6 Agricultural Water Quality Studies

A comparison was made between ground data collected from Lake Chicot, Arkansas, and Landsat TM data collected

on September 23, 1983. A preliminary analysis of limited data indicates that TM data may be useful in monitoring suspended sediment and chlorophyll in a lake with high suspended sediment loads. Total suspended loads ranged from 168 to 508 parts per million (ppm). TM band 3 appears to be most useful, with bands 1, 2, and 4 also containing useful information relative to suspended sediments. Considering water data only, bands 1, 2, and 3 appear to provide similar information. Bands 3 and 4 are also significantly related. Bands 5 and 7 appear to have independent information content relative to the presence or absence of water.

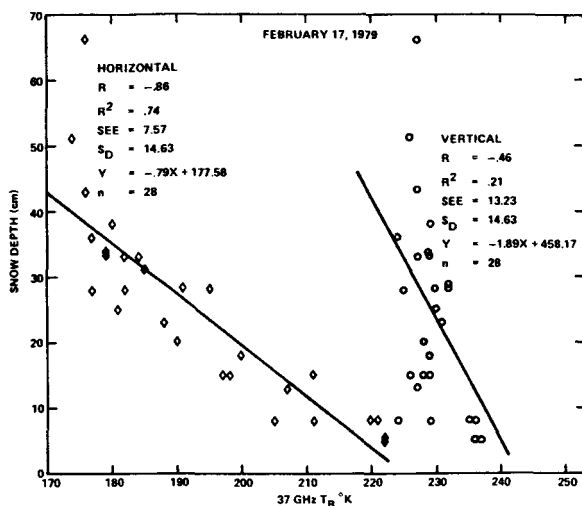


Figure 56.- A comparison of the horizontal and vertical polarizations of snow depth.

Insufficient range of water temperature ground-truth data made an evaluation of TM band 6 difficult.

TM and MSS bands 1, 2, 3, and 4 all appear to respond to changes in water quality. TM bands 1, 2, 3, and 4 appear to have overlapping information content for water sites, while TM bands 5, 6, and 7 probably provide independent, though similar, information about water sites. MSS and TM bands 1, 2, 3, and 4 were strongly correlated with each other for water sites. Thus, the main benefits of TM data, as compared to MSS data, for water sites would be gained mainly from their better ground resolution and higher quantification rather than from their separation of the spectral signal.

4.7.7 Air Pollution and Vegetation Impact

A scanning spectroradiometer specially designed for work in open-top field exposure chambers was constructed and tested late in the 1982 growing season. The laboratory-type instrument,

located in a small camper-style trailer near the field site, uses 50-meter lengths of optical fibers to reach the chambers in the field and is capable of measuring light intensities from 400 to 1100 nanometers at a 20-nanometer band width. The first reflectance spectra were obtained from soybean plants growing in open-top chambers in the field and being exposed to different low concentrations of ozone throughout the growing season. An analysis of these spectra is complete and suggest the following:

- Ozone effects on the reflectance from the soybean plants were most obvious at wavelengths between 560 and 620 nanometers (fig. 57).
- Ozone promotes early senescence. Injury is not obvious until later in the growing season. Visible injury occurs

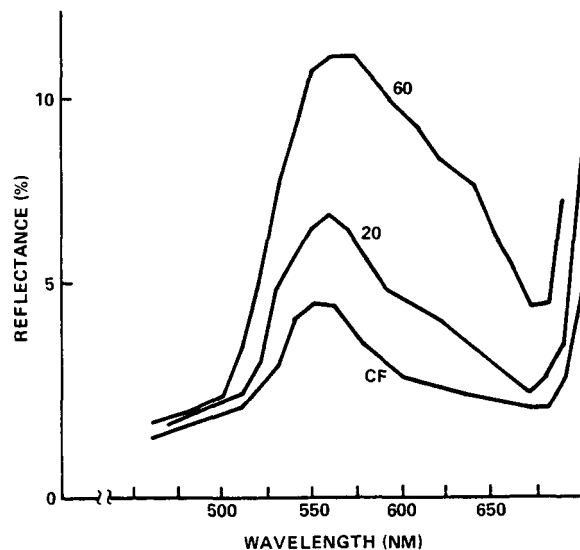


Figure 57.- Reflectance of soybeans in the visible portion of the spectrum. Plants were exposed for 7 hours per day throughout the growing season either to 20 or 60 ppb ozone or to charcoal filtered air.

earlier in the growing season, but it is generally limited to the lower leaves and is therefore not as apparent to the overhead sensor of the spectroradiometer.

- In contrast to results of earlier work with snap bean plants exposed to high

ozone concentrations for short time periods in growth chamber experiments, no differences in reflectance were observed in the near-infrared (700- to 1100-nanometer) part of the spectrum of soybean plants exposed to much lower ozone concentrations for much longer times.

APPENDIX A

AgRISTARS MANAGEMENT AND ORGANIZATION

1. INTRODUCTION

The program scope of AgRISTARS specifically addresses the seven information requirements identified by the Secretary of Agriculture.² It is structured into projects designed to conduct research, develop, test, and evaluate the various applications of aerospace technology. These projects are designed to support a decision regarding the routine use of remote sensing technology by USDA.

2. RESPONSIBILITIES

The organization and management philosophy recognizes that each involved Government agency enters into an agreement to support remote sensing research which will address the information requirements defined by the USDA. Each Government agency budgets, manages, and maintains control of the resources necessary to meet its own responsibilities as jointly agreed upon (see fig. A-1).

3. JOINT MANAGEMENT STRUCTURE/ORGANIZATION

The program utilizes the matrix management system. There are eight major projects, each having a number of tasks assigned to various line organizations of the participating agencies. Each of the eight projects has a project manager who reports to a Program Management Group (PMG). The PMG, in turn, takes its direction and guidance from the Interagency Coordinating Committee

(ICC). As viewed in figure A-2, the functional relationships are structured into a three-level management system, each having distinct responsibilities.

3.1 INTERAGENCY COORDINATING COMMITTEE

The ICC is comprised of membership from USDA, NASA, USDC, UDSI, and AID. It is chaired by the USDA and is responsible for approving AgRISTARS program objectives and establishing priorities; approving the AgRISTARS Program Plan; assessing progress, identifying problems, and developing corrective actions; and coordinating the use of resources assigned to the program.

3.2 PROGRAM MANAGEMENT GROUP

The PMG represents a joint approach to management which provides participation, project integration, and needed visibility by all participants and assures full responsiveness to USDA information requirements.

The PMG is a full-time management/coordination group responsible for a wide range of management and support activities for both the ICC and the research projects. Included are tasks related to the following areas:

- Program/Project Plans
- Change Control Function
- Project Support
- Data Requirements Consolidation
- Resources Planning and Monitoring
- Review and Reporting

²Joint Program of Research and Development of Uses of Aerospace Technology for Agricultural Programs, February 1978.

USDA	NASA	USDC
<ul style="list-style-type: none"> • DEFINITION OF USDA INFORMATION REQUIREMENTS. • YIELD MODEL RESEARCH, DEVELOPMENT, AND TESTING (RD&T) AND APPLICATIONS. • RD&T - APPLICATIONS ANALYSIS FOR AREA, YIELD, AND PRODUCTION ESTIMATION. • DEVELOPMENT OF AGRONOMIC/ANCILLARY DATA BASE. • USER EVALUATION. • GROUND DATA COLLECTION. • RD&T AND APPLICATIONS FOR CROP WEATHER ASSESSMENTS.¹ • RD&T AND APPLICATIONS FOR EW/CCA ANALYSIS. • RD&T AND APPLICATIONS FOR RRI ANALYSIS. • RD&T AND APPLICATIONS FOR LAND USE, PRODUCTIVITY AND C/P ANALYSIS. • RD&T FOR SOIL MOISTURE MEASURING TECHNIQUES. 	<ul style="list-style-type: none"> • RD&T FOR FOREIGN CROP AREA ESTIMATION. • RD&T FOR COMBINING AREA AND YIELD ESTIMATES FOR FOREIGN CROP PRODUCTION. • FIELD RESEARCH. • LANDSAT DATA ACQUISITION. • RD&T - SPECTRAL INPUTS TO YIELD MODELS. • RD&T - SPECTRAL INPUTS TO QUANTITATIVE EW/CCA. • RD&T FOR SPECTRAL ANALYSIS RELATED TO INVENTORY AND CONDITION ASSESSMENT TECHNIQUES FOR RRI. • RD&T INVENTORY AND MONITORING TECHNIQUES FOR LAND USE AND C/P. • RD&T FOR REMOTELY SENSED SOIL MOISTURE MEASURING TECHNIQUES. • DEFINITION OF REQUIREMENTS FOR FUTURE SENSORS (INCLUDING IN-SITU). 	<ul style="list-style-type: none"> • METEOROLOGICAL DATA BASE. • RD&T AND APPLICATIONS OF ENVIRONMENTAL SATELLITE DATA. • RD&T METEOROLOGICAL YIELD MODELS. • RD&T WEATHER/CROP ASSESSMENTS.² • RD&T ON USE OF CONVENTIONAL AND SATELLITE-DERIVED METEOROLOGICAL DATA APPLIED TO RRI AND C/P. • RD&T ON TECHNIQUES FOR DETERMINING SOIL MOISTURE. • LANDSAT DATA STORAGE, RETRIEVAL, AND DISSEMINATION. • EVALUATION OF UTILITY OF RD&T RESULTS FOR APPLICATIONS IN DEVELOPING COUNTRIES.

¹Primary emphasis is on assessment of crop conditions (e.g., yield, production) using meteorological data as an input to develop needed information.

²Primary emphasis is on acquisition and evaluation of meteorological data in terms of its utility for crop condition assessment.

Figure A-1.- AgRISTARS responsibilities of five Government agencies.

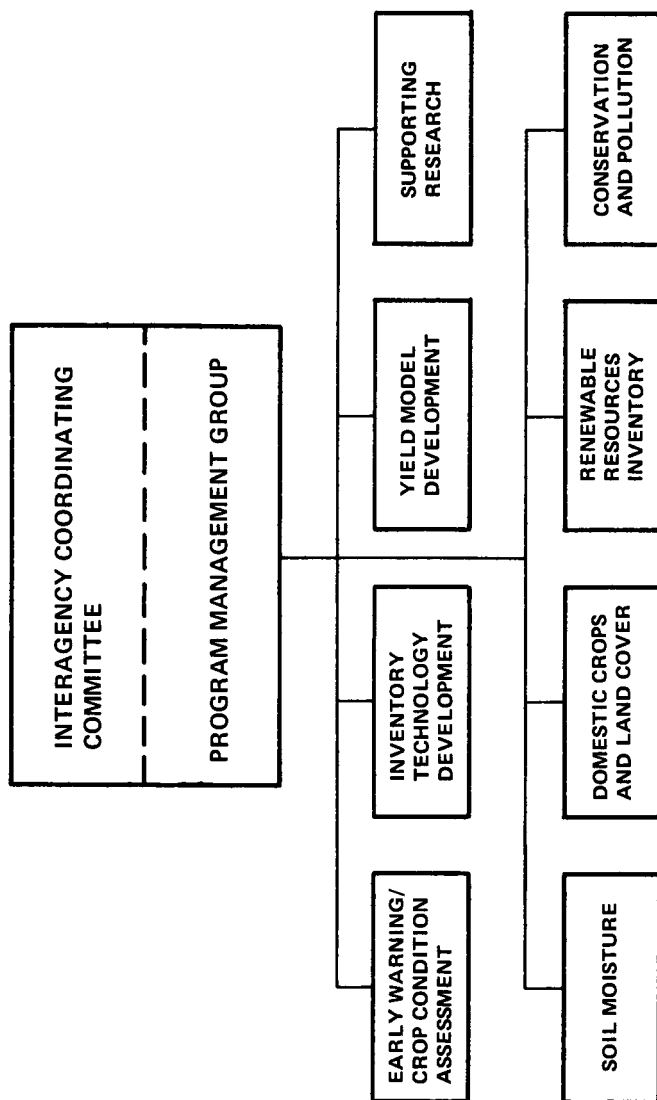


Figure A-2.- Joint agency program management and functional relationships.

4. PROJECT MANAGERS

Each of the projects is headed by a project manager whose selection from a participating agency is based principally upon considerations of technical expertise and expected levels of agency involvement. The project managers are responsible to the PMG for planning and managing activities within their projects. This includes defining project content, identifying expected projects and schedules, assessing status and progress, identifying problems, making change recommendations, planning and defining tasks, and participating with other project managers in the integration of the various projects.

5. REVIEW AND REPORTING

A review and reporting plan has been established to support major program planning and budgetary events.

Each year in the August through September period, the PMG, project managers, and task managers update the project implementation plans to reflect current budgets and the results and recommendations resulting from the various reviews.

Internal reviews are held at the various levels of management as required.

6. DOCUMENTATION

All aspects of the program are being documented in full by reports; technical memoranda and journal articles, as appropriate; press releases; and program progress reports.

7. PARTICIPATING ORGANIZATIONS

Many elements of Government, industry, and the university community are participants in AgRISTARS.

APPENDIX B

AgRISTARS PROGRAM AND PROGRAM-RELATED DOCUMENTATION

1. GENERAL

This appendix contains a by-project listing of all AgRISTARS program and program-related documentation from program inception through documentation of tasks completed in FY 1983. The listing provided has been further subdivided within each project into areas of plans, reports, procedures, etc., to facilitate easy retrieval of desired documentation.

2. REQUESTING DOCUMENTS

2.1 AgRISTARS DOCUMENTS WITH NTIS NUMBERS

Reproduction of all AgRISTARS documents with NTIS numbers should be available by writing:

National Technical Information Services
5285 Port Royal Road
Springfield, Virginia 22161

Otherwise, request documents according to instructions in sections 2.2 and 2.3.

2.2 CONTROLLED DOCUMENTS

Documents which carry an AgRISTARS control number may be obtained from NASA/JSC by either telephone or mail request. Address requests to:

Lyndon B. Johnson Space Center
SC - Documentation Manager
Houston, Texas 77058
Telephone 713-483-4776

2.3 UNNUMBERED DOCUMENTS (00900 SERIES AND PRESENTATIONS)

Requests for material within this area will be honored based upon availability of data. Requests should be made to:

Lyndon B. Johnson Space Center
(Appropriate Project)
SC - Program Management Group
Houston, Texas 77058
Telephone 713-483-2548

0. AgRISTARS PROGRAM
DOCUMENTATION (AP)

Reports

- 0-01. AgRISTARS Annual Report. AP-J0-04111, 1980. NTIS: 82N23609.
- 0-02. AgRISTARS Documents Tracking List Report. AP-L1-04116, First Edition, Feb. 1981.
- 0-03. AgRISTARS Documents Tracking List Report. AP-L1-04116, Second Edition (February, March, April, May 1981), June 1981.
- 0-04. AgRISTARS Documents Tracking List Report. AP-L1-04116, Third Edition (Through September 1981).
- 0-05. AgRISTARS Documents Tracking List Report. AP-L2-04116, Fourth Edition (Through March 1982).
- 0-06. AgRISTARS Documents Tracking List Report. AP-L2-04116, Fifth Edition (Through June 1982).
- 0-07. AgRISTARS Documents Tracking List Report. AP-L2-04116, Sixth Edition (Through December 1982).
- 0-08. Data Directory Report, AP-J1-04137, JSC-17415.
- 0-09. AgRISTARS Annual Report - Fiscal Year 1981. AP-J2-04225, Jan. 1982.
- 0-10. AgRISTARS Research Report - Fiscal Year 1982. AP-12-0393, Jan. 1983.
- 0-11. AgRISTARS Documents Tracking List Report. Seventh Edition, AP-L3-04116, JSC-18887, LEMSCO-19557, Seventh Edition (Through June 1983).

Plans

- 0-12. AgRISTARS Technical Program Plan. AP-J0-00628, JSC-17153, Jan. 15, 1980.
- 0-13. AgRISTARS Technical Program Plan - Appendix B - Data Management Plan - Volume I. AP-J0-00628-1, JSC-17153, April 11, 1980.
- 0-14. AgRISTARS Data Management Plan. AP-L1-00630, JSC-17158, May 1981.
- 0-15. AgRISTARS, First Year Achievements. MU-J1-00629, JSC-17156, June 1981.
- 0-16. AgRISTARS Program Directive (ADP), AgRISTARS Program Relationship to Foreign Countries. ADP 80-1, Dec. 4, 1979.
- 0-17. AgRISTARS Program Directive (ADP), AgRISTARS Technical Approach Definitions, ADP 80-2, Mar. 5, 1980.
- 0-18. AgRISTARS Program Directive (ADP), AgRISTARS Large Scale Applications Tests (LSAT's). ADP 80-4, Apr. 24, 1980.
- 0-19. AgRISTARS Management/Organization Plan. AP-J0-00632, JSC-17396, Jan. 15, 1980.
- 0-20. AgRISTARS Program Documentation, Management/Organization Plan, April 19, 1982. AP-J1-C0637, JSC-17419, Apr. 1982.
- 0-21. AgRISTARS Program Documentation, Program Plan, April 19, 1982. AP-J2-C0651, JSC-18224, Apr. 1982.
- 0-22. AgRISTARS Revised Program Plan. AP-J0-C0659, JSC-18578, Sept. 1982.
- 0-23. AgRISTARS Program Documentation, 1984 Program Plan. AP-J3-C0662, JSC-18898, Dec. 1983.
- 0-24. AgRISTARS Resources Plan. Nov. 5, 1980.

0-25. AgRISTARS Technical Program Plan.
AP-J9-00631, JSC-17395, Apr. 20, 1979.

1. EW/CCA

Instructions

- 1-01. Soil Moisture/Early Warning and Crop Condition Assessment Interface Control Document. MU-J0-00101, JSC-16842, Nov. 1980. NTIS: 82N19628.
- 1-02. Yield Model Development/Early Warning and Crop Condition Assessment Interface Control Document. MU-J0-00102, JSC-16843, Nov. 1980.
- 1-03. Crop Condition Query Software Documentation. EW-L2-00103, JSC-18271, LEMSCO-18618, Sept. 1982.

Reports

- 1-04. Meteorological Satellite Data - A Tool to Describe the Health of the World's Agriculture. EW-N1-04042, JSC-17112, Feb. 1981. NTIS: 81N31596.
- 1-05. Hand-Held Radiometry - A Set of Notes Developed for Use at the Workshop on Hand-Held Radiometry. EW-U1-04052, JSC-17118, Oct. 1980. NTIS: 81N28496.
- 1-06. Soil Moisture Inferences From Thermal Infrared Measurements of Vegetation Temperatures. EW-U1-04068, JSC-17125, Mar. 1981. NTIS: 81N29500.
- 1-07. Large Area Application of a Corn Hazard Model. EW-U1-04074, JSC-17130, Mar. 1981. NTIS: 81N28497.
- 1-08. The Characteristics of TIROS, GOES, DMSP, and Landsat Systems. EW-N1-04075, JSC-17131, Mar. 1981. NTIS: 81N29506.
- 1-09. The Environmental Vegetative Index - A Tool Potentially Useful for Arid Land Management. EW-N1-04076, JSC-17132, Mar. 1981. NTIS: 81N29505.
- 1-10. Canopy Temperature as a Crop Water Stress Indicator. EW-U1-04077, JSC-17133, Mar. 1981. NTIS: 81N33566.
- 1-11. Registration Verification of SEA/AR Fields. EW-L1-04101, JSC-17251, LEMSCO-16204, May 1981. NTIS: 82N21635.
- 1-12. Plant Cover, Soil Temperature, Freeze, Water Stress, and Evapotranspiration Conditions. EW-U1-04103, JSC-17143, Aug. 1981.
- 1-13. Utilization of Meteorological Satellite Imagery for Worldwide Environmental Monitoring: The Lower Mississippi River Flood of 1979. EW-N1-04104, JSC-17144, Mar. 1981. NTIS: 82N22588.
- 1-14. Techniques in the Use of NOAA 6-N Data for Crop Condition Evaluation. EW-N1-04105, JSC-17145, Apr. 1981.
- 1-15. Two Layer Soil Water Budget Model - A Tool for Large Area Soil Moisture Estimates. EW-U1-04106, JSC-17146, Apr. 1981.
- 1-16. Comparison of Landsat-2 and Field Spectrometer Reflectance Signatures of South Texas Rangeland Plant Communities. EW-U1-04107, JSC-17147, Apr. 1981.
- 1-17. Environmental Factors During Seed Development and Their Influence on Pre-Harvest Sprouting in Wheat. EW-U1-04115, JSC-17157, May 1981. NTIS: 82N22589.
- 1-18. A Meteorological Driven Maize Stress Indicator Model. EW-U1-04119, JSC-17399, Apr. 1981. NTIS: 82N23564.

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PRECEDING PAGE BLANK NOT FILMED

- 1-19. Review of Literature Relating to the Modeling of Soil Temperature Based on Meteorological Factors. EW-21-04124, NAS-916007, July 1981. NTIS: 82N22544.
- 1-20. Airborne Observed Solar Elevation and Row Direction Effects on the Near-IR/Red Ratio of Cotton. EW-U1-04144, JSC-17420, Aug. 1981. NTIS: 82N23593.
- 1-21. Agricultural Research Service Research Highlights in Remote Sensing for Calendar Year 1980. EW-R1-04147, July 1981. NTIS: 82N23601.
- 1-22. A Look At the Commonly Used Landsat Vegetation Indices. EW-L1-04134, JSC-17413, LEMSCO-16844, Oct. 1981. NTIS: 82N21657.
- 1-23. An Empirical, Graphical, and Analytical Study of the Relationships Between Vegetative Indices. EW-J1-04150, JSC-17424, Oct. 1981. NTIS: 82N22592.
- 1-24. Predicting the Timing and Potential of the Spring Emergence of Overwintered Populations of *Heliothis* Spp. EW-U1-04185, T-4629H, Apr. 1981.
- 1-25. Area Estimation of Environmental Phenomena from NOAA-n Satellite Data. EW-L1-04190, JSC-17437, LEMSCO-17312, Feb. 1982. NTIS: 82N24553.
- 1-26. A Meteorologically Driven Grain Sorghum Stress Indicator Model. EW-U1-04208, JSC-17797, Nov. 1981. NTIS: 82N23591.
- 1-27. Evaluation of the Doraiswamy-Thompson Winter Wheat Crop Calendar Model Incorporating a Modified Spring Restart Sequence. EW-U1-04212, JSC-17801, Nov. 1981. NTIS: 82N23580.
- 1-28. Two-Channel Metsat to Universal Format Conversion Program (MET2CH2UF) User's Guide. EW-L1-04215, JSC-17803, LEMSCO-17262, Dec. 1981.
- 1-29. Program RAWPLT User Guide: Plotting of Landsat, Sun-angle, and Atmospheric - Corrected Data Versus Acquisition Date. EW-L1-04216, JSC-17804, LEMSCO-17331, Apr. 1982.
- 1-30. A Review of Remote Sensing and Grasslands Literature. EW-L2-04223, JSC-17809, LEMSCO-17644, Feb. 1982. NTIS: 82N24555.
- 1-31. Increase of Cold Tolerance in Cotton Plant (*Gossypium Hirsutum* L.) by Mepiquat Chloride. EW-U2-04243, JSC-17817, Feb. 1982.
- 1-32. Reflectance Measurements of Cotton Leaf Senescence Altered by Mepiquat Chloride. EW-U2-04244, JSC-17818, Feb. 1982.
- 1-33. Preliminary Study for Correlation of Meteorological Satellite Opening (METSAT) Data With Landsat Data. EW-L2-04248, JSC-17821, LEMSCO-17307, Mar. 1982.
- 1-34. Reflectance Differences Between Target and Torch Rape Cultivars. EW-U2-04250, JSC-17823, Mar. 1982. NTIS: 82N24544.
- 1-35. Leaf Reflectance - Nitrogen - Chlorophyll Relations Among Three So. Texas Woody Rangeland Plant Species. EW-U2-04251, JSC-17824, Feb. 1982. NTIS: 82N24545.
- 1-36. Reflectance of Litter Accumulation Levels at 5 Wavelengths Within 0.5 to 2.5um Waveband. EW-U2-04252, JSC-17825, Mar. 1982. NTIS: 82N24542.
- 1-37. Optical Parameters of Leaves of Weed Species. EW-U2-04253, JSC-17826, Mar. 1982. NTIS: 82N24546.
- 1-38. Use of Landsat 2 Data Technique to Estimate Silverleaf Sunflower Infestation. EW-U2-04254, JSC-17827, Feb. 1982. NTIS: 82N24547.
- 1-39. Semi-Annual Program Review Presentation to Level 1, Interagency Coordination Committee. EW-J2-04276, JSC-17822, Apr. 19, 1982.
- 1-40. Determination of Growth and Water Stress in Wheat by Various Vegetation Indices Through a Clear and a Turbid Atmosphere. EW-U2-04298, JSC-18241, May 1982.
- 1-41. Advanced Very High Resolution Radiometer (AVHRR) Data Evaluation for Use in Monitoring Vegetation Volume 1 - Channels 1 and 2. EW-L2-04303, JSC-18243, LEMSCO-17383, May 1982.
- 1-42. Computer Program Documentation for the Flood Damage Assessment Processors. EW-L2-04312, JSC-18246, LEMSCO-18237, June 1982.
- 1-43. Influence of Environmental Factors During Seed Development and After Full-Ripeness on Pre-Harvest Sprouting in Wheat. EW-U2-04319, JSC-18254, June 1982.
- 1-44. Estimating Total Standing Herbaceous Biomass Production with Landsat MSS Digital Data. EW-U2-04320, JSC-18255, June 1982.
- 1-45. Winter Wheat Stand Density Determination and Yield Estimates from Handheld and Airborne Scanners. EW-U2-04327, JSC-18258, June 1982.
- 1-46. Optical Parameters of Leaves of Seven Weed Species. EW-U2-04328, JSC-18259, June 1982.
- 1-47. Semi-Annual Progress Report Development of An Early Warning System of Crop Moisture Conditions Using Passive Microwave. EW-T2-04329, NAS9-16556, Apr. 1982.
- 1-48. Adjusting the Tasseled Cap Brightness and Greenness Factors for Atmospheric Path Radiance and Absorption on a Pixel by Pixel Basis. EW-U2-04334, JSC-18260, July 1982.
- 1-49. Comparison of Landsat-2 and Field Spectrometer Reflectance Signature of South Texas Rangeland Plant Communities. EW-U2-04335, JSC-18261, July 1982.
- 1-50. Computer Program Documentation for the Pasture/Range Condition Assessment Processor. EW-L2-04340, JSC-18265, LEMSCO-18627, July 1982.
- 1-51. Annual Report: Agricultural Research Service - Research Highlights in Remote Sensing for Calendar Year 1981. EW-R2-04345, JSC-18268.
- 1-52. SMDATA Program Documentation. EW-L2-04346, JSC-18269, LEMSCO-18646, Sept. 1982.
- 1-53. Diurnal Patterns of Wheat Spectral Reflectance and Their Importance in the Assessment of Canopy Parameters From Remotely Sensed Observations. EW-U2-04349, JSC-18561, Sept. 1982.
- 1-54. Comparisons Among a New Soil Index and Other Two-And-Four-Dimensional Vegetation Indices. EW-U2-04350, JSC-18562, Sept. 1982.
- 1-55. Use of a Near-Infrared Video Recording System for the Detection of Freeze-Damaged Citrus Leaves. EW-U2-04351, JSC-18563, Sept. 1982.
- 1-56. Computer Program Documentation for the Option Processor. EW-L2-04357, JSC-18571, LEMSCO-18761, Sept. 1982.
- 1-57. Semi-Annual Program Review Presentation to Level 1, Interagency Coordination Committee. EW-U2-04379, JSC-18582, Nov. 1982.
- 1-58. Atmospheric Effects on Metsat Data. EW-L2-04387, JSC-18589, LEMSCO-18836, Jan. 1983.

1-59. Use of NOAA-N Satellite for Land/Water Discrimination and Flood Monitoring. EW-L2-04394, JSC-18594, LEMSCO-19032, Jan. 1983.

1-60. Bauer, A., and A. L. Black: Rain-Induced Spring Wheat Harvest Loss. EW-U3-04405, Feb. 1983.

1-61. Bauer, A., and A. L. Black: The Water Factor in Harvest-Sprouting of Hard Red Spring Wheat. EW-U3-04406, Feb. 1983.

1-62. A Meteorologically-Driven Yield Reduction Model for Spring and Winter Wheat. EW-U3-04397, JSC-18601, Feb. 1983.

1-63. METSAT Information Content: Cloud Screening and Solar Correction Investigations on the Influence of NOAA-6 Advanced Very High Resolution Radiometer Derived Vegetation Assessment. EW-L3-04402, JSC - 18606, LEMSCO-19199, Mar. 1983.

1-64. Effects of Decreasing Resolution on Spectral and Spatial Information Content in Agricultural Area. EW-L3-04415, JSC-18879, LEMSCO-19352, June 1983.

1-65. The Equivalence of Three Techniques for Estimating Ground Reflectance From Landsat Digital Count Data. EW-U3-04407, Apr. 1983.

1-66. Simulation of Meteorological Satellite (METSAT) Data Using Landsat Data. EW-L3-04414, JSC-18878, LEMSCO-16928, May 1983.

1-67. Satellite Remote Sensing Applied to Rangeland Assessment in Australia and New Zealand. EW-03-04410, Oct. 1983.

Plans

1-68. Early Warning/Crop Condition Assessment Implementation Plan. EW-J0-C0617, JSC-16852, 1980.

1-69. Early Warning/Crop Condition Assessment Implementation Plan. EW-J1-C0622, JSC-16862, 1981.

1-70. Early Warning/Crop Condition Assessment Project Implementation Plan. EW-U1-00649, JSC-17800, 1982.

1-71. Early Warning and Crop Condition Assessment Project Implementation Plan for Fiscal Year 1983. EW-U2-C0657, JSC-18566, Sept. 1982.

Procedures

1-72. Program Development and Maintenance Standards. EW-U0-00700, JSC-16367, July 1980.

1-73. Limited Area Coverage/High Resolution Picture Transmission, LAC/HRPT Tape Conversion Processor User's Manual. EW-L0-00701, JSC-16373, LEMSCO-15325, Sept. 1980. NTIS: 81N13433.

1-74. Limited Area Coverage/High Resolution Picture Transmission (LAC/HRPT) Tape IJ Grid Pixel Extraction Processor User's Manual. EW-L0-00702, JSC-16374, LEMSCO-15326, Sept. 1980. NTIS: 81N13428.

1-75. Limited Area Coverage/High Resolution Picture Transmission (LAC/HRPT) Data Vegetative Index Calculation Processor User's Manual. EW-L0-00703, JSC-16375, LEMSCO-15327, Sept. 1980. NTIS: 81N13429.

1-76. Tape Merge/Copy Processor. EW-L0-00704, JSC-16381, LEMSCO-15356, Sept. 1980. NTIS: 81N13417.

1-77. EROS to Universal Tape Conversion Processor. EW-L0-00705, JSC-16382, LEMSCO-15357, Sept. 1980. NTIS: 81N13430.

1-78. Conversion of SPU-Universal Disk File to JSC-Universal Tape Storage - CONVRT User's Guide. EW-L0-00706, JSC-16821, LEMSCO-15608, Sept. 1980. NTIS: 81N29501.

1-79. Patch Image Processor User's Manual. EW-L0-00707, JSC-16833, LEMSCO-15692, Sept. 1980. NTIS: 81N21418.

1-80. SKIP Subsampling Processor User's Manual. EW-L0-00708, JSC-16854, LEMSCO-15114, Nov. 1980.

1-81. Computer Program Documentation for the Patch Subsampling Processor. EW-L1-00709, JSC-16855, LEMSCO-15119, Jan. 1981. NTIS: 82N22541.

1-82. Wheat Stress Indicator Model, Crop Condition Assessment Division (CCAD) Data Base Interface Driver, User's Manual. EW-L1-00711, JSC-17114, LEMSCO-16034, Feb. 1981. NTIS: 82N19607.

1-83. Winterkill Indicator Model, Crop Condition Assessment Division (CCAD) Data Base Interface Driver, User's Manual. EW-L1-00711, JSC-17117, LEMSCO-16033, Mar. 1981. NTIS: 85N15492.

1-84. General Graphing System (GRAPH) User Guide. EW-L1-00716, JSC-17397, LEMSCO-16667, June 1981.

1-85. Wheat Stress Indicator Model, Early Warning (EW) Data Base Interface Driver, User's Manual. EW-L1-00732, JSC-17793, LEMSCO-17179, Nov. 1981. NTIS: 82N21652.

1-86. Winterkill Indicator Model, Early Warning (EW) Data Base Interface Driver, User's Manual. EW-L1-00733, JSC-17794, LEMSCO-17178, Nov. 1981. NTIS: 82X74779.

1-87. Two-Layer Soil Moisture Model, Early Warning (EW) Data Base Interface Driver, User's Manual. EW-L1-00734, JSC-17795, LEMSCO-17193, Nov. 1981. NTIS: 82X74780.

1-88. Flood Damage Assessment Processor's, Early Warning, User's Manual. EW-L2-00741, JSC-18225, LEMSCO-18055, Apr. 1982.

1-89. METSAT5 Program Documentation. EW-L2-00743, JSC-18238, LEMSCO-18206, May 1982.

1-90. METSAT Image Rectification Program (RECTIF) User Guide. EW-L2-00749, JSC-18252, LEMSCO-18244, May 1982.

1-91. Program SMDATA User Guide. EW-L2-00751, JSC-18262, LEMSCO-18504, July 1982.

1-92. METSAT to Universal Format User Guide. EW-L2-00753, JSC-18267, LEMSCO-18641, Sept. 1982.

1-93. Pasture/Range Condition Assessment Processor User's Manual. EW-L2-00754, JSC-18567, LEMSCO-18688, Sept. 1982.

1-94. METSAT to Universal Format Reformatting Program. EW-L2-00755, JSC-18568, LEMSCO-18690, Sept. 1982.

1-95. Data Base Model Processor System User Guide and Program Documentation. EW-L2-00756, Oct. 1982.

1-96. Computer Program Documentation for the Sugar Beet Model. EW-L3-00759, JSC-18595, LEMSCO-19029, Jan. 1983.

1-97. METCOR-4: A Program to Simulate Metsat Data. EW-L3-00762, JSC-18599, LEMSCO-18918, Jan. 1983.

1-98. Methods of Editing Cloud and Atmospheric Layer Affected Pixels From Satellite Data. EW-U2-00760, JSC-18596, Jan. 1983.

- 1-99. Sugarbeet Model Early Warning (EW) User's Manual. EW-L3-00764, JSC-18604, LEMSCO-19082, Jan. 1983.
- 1-100. Program IJMAP User Guide. EW-L3-00735, JSC-17805, LEMSCO-17264, Mar. 1983.
- 1-101. Program LPILOT User Guide: Plotting of Crop Trajectories Using Four Vegetative Indices (VIN's). EW-L3-00766, JSC-18875, LEMSCO-17311, Apr. 1983.
- 1-102. Landsat Data Preprocessing. EW-L3-04413, JSC-18877, Apr. 1983.
- 1-103. Satellite, Agronomic and Meteorological (SAM) Data Base Development Software Documentation. EW-L3-00767, JSC-18880, LEMSCO-19360, May 1983.
- 1-104. Option Program User's Manual. EW-L3-00765, JSC-18608, LEMSCO-19160, May 1983.
- 1-105. Satellite, Agronomic and Meteorological (SAM) Data Base Documentation. EW-L3-04437, JSC-18888, LEMSCO-19627, July 1983.
- 1-106. Synoptic Agronomic Model Evaluation - A Proposed Plan. EW-L3-00661, JSC-18889, June 1983.

Unnumbered Documents

- 1-107. Aase, J. K., J. P. Millard, and F. H. Siddoway: Spring Wheat Leaf Phytomass and Yield Estimates From Airborne Scanner and Handheld Radiometer Measurements. *Int. J. Remote Sens.* (in press).
- 1-108. Aase, J. K., and D. L. Tanaka: Effects of Tillage Practices on Soil and Wheat Spectral Reflectances. *Agron. J.* (in press).
- 1-109. Allen, L. H., Jr., J. F. Bartholic, R. G. Bill, Jr., A. F. Cook, H. E. Hannah, K. F. Heimberg, W. H. Henry, K. Hokkanen, F. G. Johnson, and J. W. Jones: Evapotranspiration Measurements. Florida Water Resources, NAS 10-9348, Final Report, IFAS, Univ. of Florida, in cooperation with NASA, Kennedy Space Center, South Florida Water Management District, and USDA, SEA-AR, 1980, pp. 5.6-1 to 5.6-88.
- 1-110. Allen, L. H., Jr., E. Chen, J. D. Martsolf, P. H. Jones, and T. N. Carlson: Use of Thermal Inertia Determined by HCMM to Predict Nocturnal Cold Prone Areas in Florida. HCMM Data Investigation HFO-002, contract NAS 5-26453. Prepared by Institute of Food and Agricultural Sciences, Univ. of Fla. (Gainesville) for NASA GSFC, 1983.
- 1-111. Allen, R. F., R. D. Jackson, and P. J. Pinter, Jr.: To Relate Landsat Data to U.S. Agriculture. *Agric. Eng.*, vol. 61, no. 11, 1980, pp. 12-14.
- 1-112. Bauer, A., and A. L. Black: Sprouting in Intact Mature Spikes of Hard Red Spring Wheat. *Agron. J.*, vol. 75, 1983, pp. 1016-1022.
- 1-113. Bauer, A., and A. L. Black: Rain-Induced Harvest Losses in Swathed and Standing Wheat. *North Dakota Agric. Exp. Sta. Res. Rep.* 97, 1983.
- 1-114. Bauer, A., D. Smika, and A. Black: Correlation of Five Wheat Growth Stage Scales Used in the Great Plains. USDA-ARS, AAT-NC-7, ISSN 0193-3701, 1983.
- 1-115. Boatwright, G. O., F. W. Ravet, and T. W. Taylor: Development of Early Warning Models. Wheat Yield Model Progress Report, Western Region Report, USDA-ARS (in press).
- 1-116. Brazel, A. J., and S. B. Idso: Thermal Effects of Dust on Climate. *Annals Assoc. American Geographers*, vol. 69, 1979, pp. 432-437.
- 1-117. Castle, K., N. Dinguirard, C. E. Ezra, R. G. Holm, R. D. Jackson, C. J. Kasiner, J. M. Palmer, R. Savage, and P. N. Slater: In-Progress Absolute Radiometric Inflight Calibration of the Landsat-4 Sensors. *Proc. Landsat-4 Early Results Symposium - NASA GSFC*, 1983 (in press).
- 1-118. Chen, E., L. H. Allen, Jr., J. F. Bartholic, and J. F. Gerber: Comparison of Winter Nocturnal Geostationary Satellite Infrared Surface Temperature With Shelter Height Temperature in Florida. *Remote Sensing of Environment*, vol. 13, 1983, pp. 313-327.
- 1-119. Chen, E., L. H. Allen, Jr., J. F. Bartholic, and J. F. Gerber: Delineation of Cold Prone Areas Using Nighttime SMS/GOES Thermal Data: Effects of Soils and Water. *J. Appl. Meteorol.*, vol. 21, 1982, pp. 1528-1537.
- 1-120. Chen, E., L. H. Allen, Jr., J. F. Bartholic, R. G. Bill, Jr., and R. A. Sutheland: Satellite-Sensed Winter Nocturnal Temperature Patterns of the Everglades Agricultural Area. *J. Appl. Meteorol.*, vol. 18, 1979, pp. 992-1002.
- 1-121. Davis, P. A., and L. M. Penn: Development of a Surface Insolation Estimation Technique Suitable for Application of Polar-Orbiting Satellite Data. NOAA AgRISTARS contract NA-80-SAC-00741, Washington, D.C.
- 1-122. Davis, P. A., and J. D. Tarpley: Estimation of Shelter Temperatures From Operational Satellite Sounder Data. *J. Climate and Appl. Meteorol.*, vol. 22, 1983, pp. 369-376.
- 1-123. Detection and Measurement of Changes in the Production and Quality of Renewable Final Dry Matter Accumulation - Final Report. NASA Tech. Memo. (submitted Nov. 1980).
- 1-124. Diez, J. A., W. G. Hart, S. J. Ingle, M. R. Davis, and S. Rivera: The Use of Remote Sensing in Detection of Host Plants of Mediterranean Fruit Flies in Mexico. *Proc. Fourteenth Int. Symposium on Remote Sensing of the Environment*, vol. II, 1980, p. 675.
- 1-125. Everitt, J. H., H. W. Gausman, and S. J. Ingle: Pubescence of Texas Lantana Affects Leaf Spectra and Imagery. *Proc. Ninth Biennial Workshop on Aerial Photography in the Plant Sciences* (in press).
- 1-126. Everitt, J. H., A. H. Gerbermann, and M. A. Alaniz: Microdensitometry to Identify Saline Rangelands on 70-mm Color-Infrared Aerial Film. *Photogrammetric Eng. and Remote Sensing*, vol. 47, 1981, pp. 1357-1362.
- 1-127. Everitt, J. H., A. H. Gerbermann, M. A. Alaniz, and R. L. Bowen: Using 70-mm Aerial Photography to Identify Rangeland Sites. *Photogrammetric Eng. and Remote Sensing*, 1980, pp. 1339-1348.
- 1-128. Everitt, J. H., A. H. Gerbermann, M. A. Alaniz, and R. L. Bowen: Using 70-mm Aerial Photography to Identify South Texas Rangeland Sites. *Proc. Forty-Sixth Annual Meeting of American Soc. Photogrammetry*, 1980, pp. 409-425.
- 1-129. Everitt, J. H., A. J. Richardson, and C. L. Wiegand: Inventory of Semi-Arid Rangelands in South Texas With Landsat Data. *Proc. Seventh Symposium on Machine Processing of Remotely Sensed Data*, Purdue Univ. (West Lafayette, Ind.), 1981, pp. 404-415.
- 1-130. Frank, A. B., and A. Bauer: Effect of Temperature and Fertilizer N on Apex Development in Spring Wheat. *Agron. J.*, vol. 74, 1982, pp. 504-509.

- 1-131. Gausman, H. W., J. H. Everitt, and D. E. Escobar: Seasonal Nitrogen Concentration and Reflectance of Seven Woody Plant Species. *J. Rio Grande Valley Hort. Soc.*, vol. 33, 1979, pp. 101-104.
- 1-132. Gausman, H. W., J. H. Everitt, and D. E. Escobar: Leaf Reflectance-Nitrogen-Chlorophyll Relations Among Three South Texas Woody Rangeland Plant Species. *J. Rio Grande Valley Hort. Soc.*, vol. 34, 1980, pp. 61-66.
- 1-133. Gay, C. J. A., and R. F. Day: Early Warning Soybean Stress Prediction Model. Manuscript and M.S. Thesis, Department of Industrial Engineering, Texas A&M University (College Station, Tex.), 1983.
- 1-134. Gerbermann, A. H., J. H. Everitt, and H. W. Gausman: Reflectance of Litter Accumulation Levels at Five Wavelengths Within the 0.5- to 2.5- μ m Waveband (submitted to *Photogrammetric Eng. and Remote Sensing*).
- 1-135. Goettelman, R. C., L. B. Grass, J. P. Millard, and P. R. Nixon: Comparison of Multispectral Remote-Sensing Techniques for Monitoring Subsurface Drain Conditions. NASA Tech. Memo. 84317, 1983.
- 1-136. Gray, T. L.: Land Use Mapping and Tracking With a New NOAA-7 Satellite Product. Auto Carto 5 - Environmental Assessment and Resource Management Symposium, American Society of Photogrammetry and American Congress on Surveying and Mapping (Falls Church, Va.), Aug. 22-28, 1982.
- 1-137. Gray, T. L., M. R. Helfert, and D. G. McCrary: Artificial Satellites, an Information Source for the Earth's Arable Lands and Hydrosphere (in press).
- 1-138. Gray, T. L., T. Van Cleave, and B. D. Tapley: Depicting Weather-Induced Crop Damage. RNRFS Symposium on the Application of Remote Sensing to Resource Management (Seattle, Wash.), May 22-27, 1983.
- 1-139. Hatfield, J. L., A. Perrier, and R. D. Jackson: Estimation of Evapotranspiration at One Time-of-Day Using Remotely Sensed Surface Temperatures. *Agric. Water Mgt.*, vol. 7, nos. 1-3, 1983, pp. 341-350.
- 1-140. Hatfield, J. L., R. J. Reginato, and S. B. Idso: Comparison of Long-Wave Radiation Calculation Methods Over the United States. *Water Resources Res.*, vol. 19, no. 1, 1983, pp. 285-288.
- 1-141. Hatfield, J. L., R. D. Jackson, R. J. Reginato, P. J. Pinter, Jr., and S. B. Idso: Aerodynamic and Surface Resistances of Canopies Derived From Surface Energy Balance Models. *Proc. American Meteorol. Soc. Sixteenth Conf. on Agric. and Forest Meteorol.*, 1983, pp. 51-52 (in press).
- 1-142. Hatfield, J. L., R. J. Reginato, R. D. Jackson, S. B. Idso, P. J. Pinter, Jr.: Evapotranspiration Estimates From Surface Temperature Input to a Surface Energy Balance Model. *Proc. American Meteorol. Soc. Sixteenth Conf. on Agric. and Forest Meteorol.*, 1983, pp. 79-80 (in press).
- 1-143. Hatfield, J. L., P. J. Pinter, Jr., E. Chasseray, C. E. Ezra, R. J. Reginato, S. B. Idso, and R. D. Jackson: Effects of Panicles on Infrared Thermometer Measurements of Canopy Temperature in Wheat. *Agric. Meteorol.* (in press).
- 1-144. Hatfield, J. L., E. T. Kanemasu, G. Asrar, R. D. Jackson, P. J. Pinter, Jr., R. J. Reginato, and S. B. Idso: Leaf Area Estimates from Spectral Measurements Over Various Planting Dates of Wheat. *Int. J. of Remote Sensing* (in press).
- 1-145. Hatfield, J. L., J. P. Millard, R. J. Reginato, R. D. Jackson, S. B. Idso, P. J. Pinter, Jr., and R. C. Goettelman: Spatial Variability of Surface Temperature as Related to Cropping Practice With Implications for Irrigation Management. *Proc. Fourteenth Annual Symposium on Remote Sensing of the Environment*, 1980, pp. 1311-1320.
- 1-146. Heimburg, K. F., L. H. Allen, Jr., and W. C. Huber: Evapotranspiration Estimates Based on Surface Temperature and Net Radiation: Development of Remote Sensing Methods. Pub. no. 66, Water Resource Research Center, Univ. of Fla. (Gainesville), USDI, OWRT Project no. A-040-FLA. Annual Allotment Agric., no. 14-34-0001-0110, 1982.
- 1-147. Hoffer, R. M., and C. J. Johannsen: Remote Sensing in Ecology, Univ. Ga. Press (Athens), 1969.
- 1-148. Idso, S. B.: Book Review "Boundary Layer Climates," by T. R. Ok. *Agric. Meteorol.*, vol. 22, 1980, p. 81.
- 1-149. Idso, S. B.: Carbon Dioxide and Global Temperature: What the Data Show. *J. Environmental Quality*, vol. 12, no. 2, 1983, pp. 159-163.
- 1-150. Idso, S. B.: Climatic Impact of Atmospheric CO₂. *Science*, vol. 220, no. 4599, 1983, pp. 873-875.
- 1-151. Idso, S. B.: The Climatological Significance of a Doubling of Earth's Atmospheric CO₂ Concentration. *Science*, vol. 207, 1980, pp. 1462-1463.
- 1-152. Idso, S. B.: CO₂ as an Inverse Greenhouse Gas. *Proc. Twenty-Seventh Annual Int. Technical Symposium of the Int. Soc. for Opt. Eng.* (in press).
- 1-153. Idso, S. B.: The CO₂ Greenhouse Effect: Climatic or Biological. *Proc. Annual Technical Symposium of the Irrigation Assn.*, Dec. 1983 (in press).
- 1-154. Idso, S. B.: Comments on "The Relative Effect of Solar Altitude on Surface Temperatures and Energy Budget Components on the Two Contrasting Landscapes." *Boundary-Layer Meteorol.*, vol. 25, no. 4, 1983, pp. 423-425.
- 1-155. Idso, S. B.: Do Increases in Atmospheric CO₂ Have a Cooling Effect on Surface Temperatures? *Climatological Bull.* (in press).
- 1-156. Idso, S. B.: An Empirical Evaluation of Earth's Surface Air Temperature Response to an Increase in Atmospheric Carbon Dioxide Concentration. *Air Conference Proc. no. 82: Interpretation of Climate and Photochemical Models, Ozone and Temperature Measurements* (R. A. Reck and J. R. Hummel, eds.), American Inst. Phys. (New York), 1982, pp. 119-134.
- 1-157. Idso, S. B.: Evaluating Evapotranspiration Rates. *Proc. Deep Percolation Symposium* (Scottsdale, Ariz.), Rep. 1, Ariz. Dept. of Water Resources, 1980, pp. 25-36.
- 1-158. Idso, S. B.: Humidity Measurement by Infrared Thermometry. *Remote Sensing of Environment*, vol. 12, 1982, pp. 87-91.
- 1-159. Idso, S. B.: Non-Water-Stressed Baselines: A Key to Measuring and Interpreting Plant Water Stress. *Agric. Meteorol.*, vol. 27, 1982, pp. 59-70.
- 1-160. Idso, S. B.: On the Apparent Incompatibility of Different Atmospheric Thermal Radiation Data Sets. *Quart. J. Roy. Meteorol. Soc.*, vol. 106, 1980, pp. 375-376.
- 1-161. Idso, S. B.: On Trusting Models or Observations. *Atmospheric Environment*, vol. 17, no. 5, 1983, pp. 1025-1026.

- 1-162. Idso, S. B.: Physiological Stresses in Plants Due to Water Insufficiency and Their Detection and Quantification by Remote Sensing of Foliage Temperature. *Problems in Crop Physiology*, vol. 2 (U.S. Gupta, ed.), Oxford & IBH Pub. Co. (New Delhi, India) (in press).
- 1-163. Idso, S. B.: Relative Rates of Evaporative Water Losses From Open and Vegetation-Covered Bodies. *Water Resources Bull.* (in press).
- 1-164. Idso, S. B.: Reply to A. J. Crane's "Comments on Recent Doubts About the CO₂ Greenhouse Effect." *J. Appl. Meteorol.*, vol. 21, 1982, p. 748.
- 1-165. Idso, S. B.: Reply to Two "Letters to the Editor" of Science in Regards to a Paper of S. B. Idso on "Carbon Dioxide and Climate." *Science*, vol. 210, 1980, pp. 7-8.
- 1-166. Idso, S. B.: A Set of Equations for Full Spectrum and 8-14 Micron and 10.5-12.5 Micron Thermal Radiation From Cloudless Skies. *Water Resources Res.*, vol. 17, no. 2, Apr. 1981, pp. 295-304.
- 1-167. Idso, S. B.: Shortcoming of CO₂-Climate Models Raise Questions About the Wisdom of Their Energy Policy Implications. *Appl. Energy* (in press).
- 1-168. Idso, S. B.: Temperature Limitation by Evaporation in Hot Climates and the Greenhouse Effects of Water Vapor and Carbon Dioxide. *Agric. Meteorol.*, vol. 27, 1982, pp. 105-109.
- 1-169. Idso, S. B.: Terrain Sensing, Remoter. McGraw-Hill Yearbook of Science and Technology (D. N. Lopedes, ed.), 1979, pp. 392-393.
- 1-170. Idso, S. B., and J. A. Quinn: Vegetational Redistribution in Arizona and New Mexico in Response to a Doubling of the Atmospheric CO₂ Concentration. *Scientific Publication Series of the ASU Laboratory of Climatology*, Paper no. 17, 1983, pp. 1-52.
- 1-171. Idso, S. B., R. J. Reginato, and S. M. Farah: Soil- and Atmosphere-Induced Plant Water Stress in Cotton as Inferred From Foliage Temperatures. *Water Resources Res.*, vol. 18, 1982, pp. 1143-1148.
- 1-172. Idso, S. B., R. J. Reginato, and J. W. Radin: Leaf Diffusion Resistance and Photosynthesis in Cotton as Related to a Foliage Temperature Based Plant Water Stress Index. *Agric. Meteorol.*, vol. 27, 1982, pp. 27-34.
- 1-173. Idso, S. B., P. J. Pinter, Jr., R. D. Jackson, and R. J. Reginato: Estimation of Grain Yields by Remote Sensing of Crop Senescence Rates. *Remote Sensing of Environment*, vol. 9, 1980, pp. 87-91.
- 1-174. Idso, S. B., R. J. Reginato, R. D. Jackson, and P. J. Pinter, Jr.: Foliage and Air Temperatures: Evidence for a Dynamic "Equivalence Point." *Agric. Meteorol.*, vol. 24, 1981, pp. 223-226.
- 1-175. Idso, S. B., R. J. Reginato, R. D. Jackson, and P. J. Pinter, Jr.: Measuring Yield-Reducing Plant Water Potential Depressions in Wheat by Infrared Thermometry. *Irrigation Sci.*, vol. 2, 1981, pp. 205-212.
- 1-176. Idso, S. B., R. J. Reginato, D. C. Peicosky, and J. L. Hatfield: Determining Soil-Induced Plant Water Potential Depressions in Alfalfa by Means of Infrared Thermometry. *Agron. J.*, vol. 73, 1981, pp. 826-830.
- 1-177. Idso, S. B., R. D. Jackson, P. J. Pinter, Jr., R. J. Reginato, and J. L. Hatfield: Normalizing the Stress-Degree-Day Parameter for Environmental Variability. *Agric. Meteorol.*, vol. 24, 1981, pp. 45-55.
- 1-178. Idso, S. B., R. J. Reginato, J. L. Hatfield, C. K. Walker, R. D. Jackson, and P. J. Pinter, Jr.: A Generalization of the Stress-Degree-Day Concept of Yield Prediction to Accommodate a Diversity of Crops. *Agric. Meteorol.*, vol. 21, 1980, pp. 205-211.
- 1-179. Ingle, S. J.: Trabajos hechos de la percepcion remota. Presented at Third Simposio de Prasitologic Agricola (Monterrey, Mexico), 1980.
- 1-180. Jackson, R. D.: Assessing Moisture Stress in Wheat With Hand-Held Radiometers. *Soc. Photo-Optical Instrum. Eng.*, vol. 356, 1983, pp. 138-142.
- 1-181. Jackson, R. D.: Canopy Temperature and Crop Water Stress. *Advances in Irrigation* (D. I. Hillel, ed.), Academic Press, 1982, pp. 43-85.
- 1-182. Jackson, R. D.: Interaction Between Canopy Geometry and Thermal Infrared Measurements. *Proc. Int. Colloq. Spectral Signatures of Objects in Remote Sensing* (Avignon, France), Sept. 8-11, 1981, pp. 291-302.
- 1-183. Jackson, R. D.: Plant Health: A View From Above. Challenging Problems in Plant Health (L. Kommedahl and P. H. Williams, eds.), American Phytopathological Soc., (St. Paul, Minn.), 1983, pp. 206-214.
- 1-184. Jackson, R. D.: Soil Moisture Inferences From Thermal Infrared Measurements of Vegetative Temperatures. *Proc. 1981 Int. Geoscience Remote Sensing Symposium*, June 8-10, 1981. *Also*, *Geoscience and Remote Sensing*, vol. GE-20, 1982, pp. 282-286.
- 1-185. Jackson, R. D.: Spectral Indices in N-Space. *Remote Sensing of Environment*, vol. 13, 1983, pp. 409-421.
- 1-186. Jackson, R. D.: Superbird on the Job. 1981 Yearbook of Agriculture, 1981, pp. 116-118.
- 1-187. Jackson, R. D., and P. J. Pinter, Jr.: Detection of Water Stress in Wheat by Measurement of Reflected Solar and Emitted Thermal IR Radiation. *Proc. Int. Colloq. on Spectral Signatures of Objects in Remote Sensing* (Avignon, France), Sept. 8-11, 1981, pp. 399-406.
- 1-188. Jackson, R. D., and R. J. Reginato: Agronomic Aspects of Thermal-IR Measurements. *Proc. Second Int. Colloq. of Spectral Signatures of Objects in Remote Sensing* (in press).
- 1-189. Jackson, R. D., and J. W. Youngblood: Agriculture's Eye in the Sky. *Crops and Soils Mag.*, vol. 36, no. 1, 1983, pp. 15-18.
- 1-190. Jackson, R. D., V. V. Salomonson, and T. J. Schmugge: Irrigation Management - Future Techniques. *Proc. American Soc. Agric. Eng. Second Nat. Irrigation Symposium* (Lincoln, Neb.), Oct. 1980, *Irrigation Challenges in the 80's*, pp. 197-212.
- 1-191. Jackson, R. D., P. N. Slater, and P. J. Pinter, Jr.: Adjusting the Tasseled Cap Brightness and Greenness Factors for Atmosphere Path Radiance and Absorption on a Pixel by Pixel Basis. *Int. J. of Remote Sensing*, vol. 4, no. 2, 1983, pp. 313-323.
- 1-192. Jackson, R. D., P. N. Slater, and P. J. Pinter, Jr.: Discrimination of Growth and Water Stress in Wheat by Various Vegetation Indices Through Clear and Turbid Atmospheres. *Remote Sensing of Environment*, vol. 13, no. 3, 1983, pp. 187-208.
- 1-193. Jackson, R. D., S. B. Idso, R. J. Reginato, and P. J. Pinter, Jr.: Canopy Temperature as a Crop Water Stress Indicator. *Water Resources Res.*, vol. 17, no. 4, 1981, pp. 1133-1138.

- 1-194. Jackson, R. D., S. B. Idso, R. J. Reginato, and P. J. Pinter, Jr.: Remotely Sensed Crop Temperatures and Reflectances as Inputs to Irrigation Scheduling. *Proc. American Soc. Civil Eng. Specialty Conf. (Boise, Idaho)*, July 23-25, 1980, pp. 390-397.
- 1-195. Jackson, R. D., C. A. Jones, G. Uehara, and L. T. Santos: Remote Detection of Nutrient and Water Deficiencies in Sugarcane Under Variable Cloudiness. *Remote Sensing of Environment*, vol. 11, 1980, pp. 327-331.
- 1-196. Jackson, R. D., P. J. Pinter, Jr., R. J. Reginato, S. B. Idso: Hand-Held Radiometry. *Agric. Reviews and Manuals-W-19*, Oct. 1980.
- 1-197. Jackson, R. D., J. L. Hatfield, R. J. Reginato, S. B. Idso, and P. J. Pinter, Jr.: Estimation of Daily Evapotranspiration From One-Time-of-Day Measurements. *Agric. Water Mgt.*, vol. 7, nos. 1-3, 1983, pp. 351-362.
- 1-198. Justus, C. G., and J. D. Tarpley: Accuracy and Availability of Solar Radiation Data From Satellites and From Forecast Estimates. *AMS Atmospheric Radiation Conf. (Baltimore, Md.)* Oct. - Nov. 1983.
- 1-199. Kimball, B. A.: Carbon Dioxide and Agricultural Yield: An Assemblage and Analysis of 430 Prior Observations. *Agron. J.*, vol. 75, 1983, pp. 779-788.
- 1-200. Kimball, B. A., and S. B. Idso: Increasing Atmospheric CO₂: Effects on Crop Yield, Water Use and Climate. *Agric. Water Mgt.*, vol. 7, nos. 1-3, 1983, pp. 55-72.
- 1-201. Kimes, D. S., B. L. Markham, C. J. Tucker, and J. E. McMurtrey III: Temporal Relationships Between Spectral Response and Agronomic Variables of a Corn Canopy. *Remote Sensing of Environment* (submitted Aug. 1980).
- 1-202. Kimes, D. S., S. B. Idso, P. J. Pinter, Jr., R. D. Jackson, and R. J. Reginato: Complexities of Nadir-Looking Radiometric Temperature Measurements of Plant Canopies. *Appl. Optics*, vol. 19, 1980, pp. 2162-2168.
- 1-203. Kimes, D. S., S. B. Idso, P. J. Pinter, Jr., R. J. Reginato, and R. D. Jackson: View Angle Effects in the Radiometric Measurement of Plant Canopy Temperatures. *Remote Sensing of Environment*, vol. 10, 1980, pp. 273-284.
- 1-204. Kimes, D. S., W. W. Newcomb, J. B. Schutt, P. J. Pinter, Jr., and R. D. Jackson: Directional Reflectance Distributions of a Cotton Row Crop. *Int. J. of Remote Sensing* (in press).
- 1-205. Kirchner, J. A., D. S. Kimes, and J. E. McMurtrey III: Variation of Directional Reflectance Factors With Structural Changes of a Developing Alfalfa Canopy. *Appl. Optics*, vol. 21, Oct. 1982, pp. 3766-3774.
- 1-206. The Large Area Operational Application of the Winterkill Model Using Realtime Data and Evaluation of the Results. *USDA FAS-CCAD Tech. Memo. 13*, Nov. 1980.
- 1-207. Lautenschlager, L. F.: Comparison of Vegetative Indices, *AgRISTARS Early Warning Reviews*, Apr. 1981.
- 1-208. Lautenschlager, L. F.: Correlations Between Vegetative Indices and Plant Components, *AgRISTARS Early Warning Reviews*, May 1980 and Apr. 1981.
- 1-209. Lautenschlager, L. F.: Sampling Full-Frame Data, *AgRISTARS Early Warning Reviews*, May 1980 and Apr. 1981.
- 1-210. Leamer, R. W., and J. R. Noriega: Reflectance Brightness Measured Over Agricultural Areas. *Agric. Meteorol.*, vol. 23, 1981, pp. 1-8.
- 1-211. LeMaster, E. W., J. E. Chance, and C. L. Wiegand: A Seasonal Verification of the Suits Spectral Reflectance Model for Wheat. *Photogrammetric Eng. and Remote Sensing*, vol. 46, no. 1, 1980, pp. 107-114.
- 1-212. R. F. Liston (Forest Service, USDA): Final Report - Methods for Determination of REU Survey Plot and County Boundary Coordinates, Sept. 1980.
- 1-213. Malila, W. A., P. F. Lambeck, E. P. Crist, R. D. Jackson, and P. J. Pinter, Jr.: Landsat Features for Agricultural Applications. *Proc. Fourteenth Annual Symposium on Remote Sensing of the Environment*, 1980, pp. 793-803.
- 1-214. Marcus, K. G., W. J. Wiebold, J. E. McMurtrey III, and D. Deering: Effects of Moisture Stress History on Soybeans. *Agron. Abstr.*, Aug. 1983, p. 14.
- 1-215. Markham, B. L., D. S. Kimes, C. J. Tucker, and J. E. McMurtrey III: The Relationship of Temporal Spectral Response of a Corn Canopy to Grain Yield and Final Dry Matter Accumulation. *NASA Tech. Memo.* (submitted Nov. 1980).
- 1-216. McCrary, D. G., M. R. Helfert, T. I. Gray, and D. Conte: An Evaluation of the NOAA Polar-Orbiter as a Tool for Mapping Freeze Damage in Florida During January 1982. *Proc. Auto Carto 5 - Environmental Assessment and Resource Management* (sponsored by American Society of Photogrammetry and American Congress on Surveying and Mapping) (Falls Church, Va.), Aug. 22-28, 1982, pp. 715-722.
- 1-217. McFarland, J. C., R. D. Watson, A. F. Theisen, R. D. Jackson, W. L. Ehrler, P. J. Pinter, Jr., S. B. Idso, and R. J. Reginato: Plant Stress Detection by Remote Measurement of Fluorescence. *Appl. Optics*, vol. 19, 1980, pp. 3287-3289.
- 1-218. McMurtrey, J. E., III, E. W. Chappelle, W. W. Newcomb, and F. M. Wood, Jr.: Laser Induced Fluorescence Sensing of Nutrient Deficiencies in Corn and Soybeans. *Agron. Abstr.*, Aug. 1983, p. 14.
- 1-219. Meyerdirk, D. E., J. B. Kreasky, and W. G. Hart: Whiteflies (Aleyrodidae) Attacking Citrus in Southern Texas With Notes on Natural Enemies. *Southwest Entomol.* (in press).
- 1-220. Millard, J. P., R. J. Reginato, S. B. Idso, R. D. Jackson, R. C. Goettelman, and M. J. LeRoy: Experimental Relations Between Airborne and Ground Measured Wheat Canopy Temperatures. *Photogrammetric Eng. and Remote Sensing*, vol. 46, 1980, pp. 221-224.
- 1-221. Multiresource Inventory Methods Pilot Test (Phase 1), Final Report. *Earth Satellite Corporation*, Oct. 1980.
- 1-222. Musick, J. T., and R. A. Dusek: Planting Date and Water Deficit Effects on Development and Field of Irrigated Winter Wheat. *Agron. J.*, vol. 74, 1980, pp. 45-52.
- 1-223. Myers, V. I.: Manual of Remote Sensing, Chapter 5. *American Soc. of Photogrammetry*, 1975.
- 1-224. Nixon, P. R., D. E. Escobar, R. L. Bowen, and A. J. Richardson: Video Color Infrared Imagery: A Future Natural Resource Management Tool. *Proc. Ninth Biennial Workshop on Color Aerial Photography in the Plant Sciences* (sponsored by American Society of Photogrammetry) Nov. 15-17, 1983 (in press).
- 1-225. Nixon, P. R., B. G. Goodier, and W. A. Swanson: Midday Surface Temperatures and Energy Changes in a Residential Landscape. *J. Rio Grande Valley Hort. Soc.*, vol. 34, 1980, p. 39.

- 1-226. Pinter, P. J., Jr.: Monitoring the Effect of Water Stress on the Growth of Alfalfa Via Remotely Sensed Observations of Canopy Reflectance and Temperature. *Proc. American Meteorol. Soc. Sixteenth Conf. on Agric. and Forest Meteorol.* (Ft. Collins, Colo.), 1983, pp. 91-94.
- 1-227. Pinter, P. J., Jr.: Remote Sensing of Microclimatic Stress. *Biometeorology In Integrated Pest Management.* (J. L. Hatfield and I. J. Thomason, eds.), Academic Press, 1982, pp. 101-145.
- 1-228. Pinter, P. J., Jr., and R. D. Jackson: Dew and Vapor Pressure as Complicating Factors in the Interpretation of Spectral Radiance From Crops. *Proc. Fifteenth Int. Symposium on Remote Sensing of the Environment*, 1982, pp. 547-554.
- 1-229. Pinter, P. J., Jr., and R. J. Reginato: Thermal Infrared Techniques for Assessing Plant Water Stress. *Proc. Irrigation Scheduling Conf., American Soc. Agric. Eng.* (St. Joseph, Mo.), 1981, pp. 1-9.
- 1-230. Pinter, P. J., Jr., and R. J. Reginato: A Thermal Infrared Technique for Monitoring Cotton Water Stress and Scheduling Irrigations. *Trans. ASAE*, vol. 25, no. 6, 1982, pp. 1651-1655.
- 1-231. Pinter, P. J., Jr., K. E. Fry, G. Guinn, and J. R. Mauney: Infrared Thermometry: A Remote Sensing Technique for Predicting Yield in Water Stressed Cotton. *Agric. Water Mgt.*, vol. 6, 1983, pp. 385-395.
- 1-232. Pinter, P. J., Jr., R. D. Jackson, S. B. Idso, and R. J. Reginato: Diurnal Patterns of Wheat Spectral Reflectances. *IEEE Trans. Geoscience and Remote Sensing*, vol. GE-21, no. 2, 1983, pp. 156-163.
- 1-233. Pinter, P. J., Jr., R. D. Jackson, S. B. Idso, and R. J. Reginato: Multidate Spectral Reflectances as Predictors of Yield in Water Stressed Wheat and Barley. *Int. J. Remote Sensing*, vol. 2, no. 1, 1981, pp. 43-48.
- 1-234. Reginato, R. J.: Field Quantification of Crop Water Stress. Presentation 1982 ASAE Summer Meeting (Madison, Wis.). *Trans. ASAE*, vol. 26, no. 3, 1983, pp. 772-775, 781.
- 1-235. Reginato, R. J.: Improving Irrigation Efficiency Through Remote Sensing. *Proc. Thirty-Fifth Annual NACD Conf.*, Feb. 1-5, 1981, pp. 66-67.
- 1-236. Reginato, R. J.: Remote Assessment of Soil Moisture. *Proc. Seminar on Isotope and Radiation Techniques in Soil Water Studies* (Khartoum, Sudan) 1979. A technical document issued by the Int. Atomic Energy Agency (Vienna), 1980, pp. 76-85.
- 1-237. Reginato, R. J.: A Remote Sensing Technique for Agriculture. *Proc. Fortieth Annual Convention of National Peach Council* (Phoenix, Ariz.), 1981, pp. 129-138.
- 1-238. Richardson, A. J.: Measurement of Reflectance Factors Under Daily and Intermittent Irradiance Variations. *Appl. Optics*, vol. 20, no. 19, 1981, pp. 3336-3340.
- 1-239. Richardson, A. J.: Relating Landsat Digital Count Values to Ground Reflectance for Optically Thin Atmospheric Conditions. *Appl. Optics*, vol. 21, no. 8, 1982, pp. 1457-1464.
- 1-240. Richardson, A. J., and H. W. Gausman: Reflectance Differences Between Untreated and Mepiquat Chloride-Treated, Field Grown Cotton Through a Growing Season. *Remote Sensing of Environment*, vol. 12, 1982, pp. 501-507.
- 1-241. Wiegand, C. L., P. R. Nixon, and R. D. Jackson: Drought Detection and Quantification by Reflectance and Thermal Responses. *Agric. Water Mgt.*, vol. 7, 1983, pp. 303-321.
- 1-242. Richardson, A. J., J. H. Everitt, and H. W. Gausman: Radiometric Estimation of Biomass and Nitrogen Content of Alicia Grass. *Remote Sensing of Environment*, vol. 13, 1983, pp. 178-179.
- 1-243. Richardson, A. J., D. E. Escobar, H. W. Gausman, and J. H. Everitt: Comparison of Landsat-2 and Field Spectrometer Reflectance Signatures of South Texas Rangeland Plant Communities. *Sixth Annual Symposium on Machine Processing of Remotely Sensed Data*, Purdue Univ. (W. Lafayette, Ind.), June 3-6, 1980.
- 1-244. Richardson, A. J., C. L. Wiegand, G. F. Arkin, P. R. Nixon, and A. H. Gerbermann: Remotely-Sensed Spectral Indicators of Sorghum Development and Their Use in Growth Modeling. *Agric. Meteorol.*, vol. 26, 1982, pp. 11-23.
- 1-245. Sharratt, B. S., R. J. Hanks, and J. K. Aase: Environmental Factors Associated With Yield Differences Between Seeding Dates of Spring Wheat. *Utah State Univ. Res. Rep.* (in press).
- 1-246. Slater, P. N., and R. D. Jackson: Atmospheric Effects on Radiation Reflected From Soil and Vegetation as Measured by Orbital Sensors Using Various Scanning Directions. *Appl. Optics*, vol. 21, no. 21, 1982, pp. 3923-3931.
- 1-247. Slater, P. N., and R. D. Jackson: Transforming Ground-Measured Reflectances to Radiances Measured by Various Space Sensors Through Clear and Turbid Atmospheres. *Proc. Int. Colloq. on Spectral Signatures of Objects in Remote Sensing* (Avignon, France), 1981, pp. 531-542.
- 1-248. Smika, D. E., and Shawcroft, R. W.: Preliminary Study Using a Wind Tunnel to Determine the Effect of Hot Wind on a Wheat Crop. *Field Crops Res.*, vol. 3, 1980, pp. 129-134.
- 1-249. Tarpley, J. D.: Estimating Incident Solar Radiation at the Surface From Geostationary Satellite Data. *J. Appl. Meteorol.*, vol. 18, 1979, pp. 1172-1181.
- 1-250. Tarpley, J. D.: Satellite-Derived Insolation for Agriculture: An Update on the NESS Program. *Satellites and Forecasting of Solar Radiation*, Int. Solar Energy Soc. (Washington, D.C.), 1981.
- 1-251. Tucker, C. J., J. H. Elgin, Jr., and J. E. McMurtrey III: Relationship of Crop Radiance to Alfalfa Agronomic Values. *Int. J. Remote Sensing*, vol. 1, no. 1, 1980, pp. 69-75.
- 1-252. Tucker, C. J., B. N. Holben, J. H. Elgin, Jr., and J. E. McMurtrey III: Relationship of Spectral Data to Grain Yield Variation. *Photogrammetric Eng. and Remote Sensing*, vol. 46, no. 5, 1980, pp. 657-666.
- 1-253. Tucker, C. J., B. N. Holben, J. H. Elgin, Jr., and J. E. McMurtrey III: Remote Sensing of Total Dry-Matter Accumulation in Winter Wheat. *NASA Tech. Memo.* 80631, Jan. 1980. Also, *Remote Sensing of Environment*, vol. 11, Mar. 1981, pp. 171-189.
- 1-254. Wang, J. R., J. C. Shiue, and J. E. McMurtrey III: Microwave Remote Sensing of Soil Moisture Content Over Bare and Vegetated Fields. *NASA Tech. Memo.* 80669, Mar. 1980.

- 1-255. Wang, J. R., T. J. Schmugge, W. I. Gould, W. S. Glazar, J. E. Fuchs, and J. E. McMurtrey III: A Multi-Frequency Radiometric Measurement of Soil Moisture Content Over Bare and Vegetated Fields. *Geophys. Res. Letters*, vol. 9, Apr. 1982, pp. 416-419.
- 1-256. Wang, J. R., J. E. McMurtrey III, E. T. Engman, T. J. Jackson, T. J. Schmugge, W. I. Gould, J. E. Fuchs, and W. S. Glazar: Radiometric Measurements Over Bare and Vegetated Fields at 1.4-GHz and 5-GHz Frequencies. *Remote Sensing of Environment*, vol. 12, Mar. 1982, pp. 295-311.
- 1-257. Wiegand, C. L.: Candidate Spectral Inputs to Agrometeorological Crop Growth/Yield Models. *Proc. Int. Colloq. Spectral Signatures (Bordeaux, France)*, Sept. 12-16, 1983 (in press).
- 1-258. Wiegand, C. L., and J. A. Cuellar: Direction of Grain Filling and Kernel Weight of Wheat as Affected by Temperature. *Crop Sci.*, vol. 21, 1981, pp. 94-101.
- 1-259. Wiegand, C. L., and A. J. Richardson: Comparisons Among a New Soil Index and Other Two- and Four-Dimensional Vegetation Indices. *Tech. papers ACSM-ASP Convention*, 1982, pp. 210-227.
- 1-260. Wiegand, C. L., and A. J. Richardson: Leaf Area, Light Interception, and Yield Estimates From Spectral Components Analysis. *Agron. J.* (accepted).
- 1-261. Wiegand, C. L., A. H. Gerbermann, and J. A. Cuellar: Development and Yield of Hard Red Winter Wheats Under Semitropical Conditions. *Agron. J.*, vol. 73, no. 1, 1981, pp. 29-38.
- 1-262. Wiegand, C. L., P. R. Nixon, and R. D. Jackson: Drought Detection and Quantification by Reflectance and Thermal Responses. *Agric. Water Mgt.*, vol. 7, nos. 1-3, 1983, pp. 303-321.
- 1-263. Wiegand, C. L., P. R. Nixon, H. W. Gausman, L. N. Namken, R. W. Leamer, and A. J. Richardson: Heat Capacity Mapping Mission Plant Cover, Soil Temperature, Freeze, Water Stress, and Evapotranspiration Conditions. Type III final report (draft) for contract period Dec. 1, 1977, to Sept. 1, 1980. Nov. 1980.
- 1-264. Wiegand, C. L., L. F. Lautenschlager, P. J. Pinter, Jr., J. K. Aase, R. D. Jackson, J. E. McMurtrey III, A. J. Richardson, and D. E. Smika: Development of Agrometeorological Model Inputs From Remotely Sensed Information. *Wheat Yield Model Progress Report*, Western Region Report, USDA-ARS (in press).
- 1-265. Wolf, W. W.: Entomological Radar Observations in Arizona During 1979. *Joint Meeting Roy. Entomol. Soc., Roy. Meteorol. Soc., and British Trust for Ornithology*, Imperial College (London, England), Nov. 19, 1980.
- 1-266. Yates, H. W., J. D. Tarpley, S. R. Schneider, D. F. McGinnis, and R. A. Scofield: The Role of Meteorological Satellites in Agricultural Remote Sensing. *Remote Sensing of Environment*, vol. 14, 1984 (in press).
- 1-267. Youngblood, J. W., and R. D. Jackson: Airborne Reconnaissance in the Civilian Sector: Agricultural Monitoring From High-Powered Platforms. *Proc. Twenty-Seventh Int. Tech. Symposium of the Soc. of Photo-Optical Instrum. Eng.* (in press).

2. ITD

Task Descriptions

- 2-01. ERSYS-SPP Access Method Subsystem Design Specification. MU-11-00300, Sept. 1980.
- 2-02. "As-Built" Design Specification for Proportion Estimate Processor. FC-L1-00310, Nov. 1981. NTIS: 82X74791.
- 2-03. "As-Built" Design Specification for a PIA Modified Display Subsystem. FC-L1-00311, Nov. 1981. NTIS: 82X74793.
- 2-04. Corn/Soybeans Decision Logic: Improvements and New Crops. FC-L0-00420, JSC-16301, LEMSCO-14084, Jan. 1980. NTIS: 80N23744.
- 2-05. Evaluation of Transition Year Canadian Test Sites. FC-L0-00422, JSC-16338, LEMSCO-14320, Apr. 1980. NTIS: 80N26718.
- 2-06. Evaluation of Results of U.S. Corn and Soybeans Exploratory Experiment - Classification Procedures Verification Test. FC-L0-00423, JSC-16339, LEMSCO-14386, Sept. 1980. NTIS: 81N13432.
- 2-07. Estimation of Within-Stratum Variance for Sample Allocation. FC-L0-00428, JSC-16343, LEMSCO-14067, July 1980. NTIS: 81N12516.
- 2-08. Profile Similarity Feasibility Study. FC-L0-00429, JSC-16246, LEMSCO-14010, Feb. 1980.
- 2-09. Statistical Outlier Detection (SOD): A Computer Program for Detecting Outliers in Data. FC-L0-00432, JSC-16346, LEMSCO-14594, June 1980. NTIS: 80N30848.
- 2-10. FCPF February 1980 Task Manager's Report. FC-J0-00433, JSC-16347.
- 2-11. Semi-Annual Project Management Report, Program Review Presentation to Level 1, Interagency Coordination Committee. FC-J0-00436, JSC-16350, Mar. 1980.
- 2-12. Houston Area Multicrop Inspection Trips. FC-L0-00437, JSC-16351, LEMSCO-14584, July 1980. NTIS: 81N12480.
- 2-13. The Integrated Analysis Procedure for Identification of Spring Small Grains and Barley. FC-L0-00451, JSC-16360, LEMSCO-14385, May 1980. NTIS: 80N30847.
- 2-14. Australian Transition Year Special Study. FC-L0-00464, JSC-16368, LEMSCO-14808, Jan. 1981. NTIS: 81N33565.
- 2-15. Stratum Variance Estimation for Sample Allocation in Crop Surveys. FC-J0-00468, JSC-16371, LEMSCO-14966, July 1980. NTIS: 81N12517.
- 2-16. Evaluation of the Procedure for Separating Barley From Other Spring Small Grains. FC-L0-00472, JSC-16752, LEMSCO-14598, Aug. 1980. NTIS: 82N23603.
- 2-17. Transition Year Labeling Error Characterization Study Final Report. FC-L0-00479, JSC-16379, LEMSCO-14056, Oct. 1980. NTIS: 82N21651.
- 2-18. Corn/Soybean Decision Logic Development and Testing. FC-L0-00480, JSC-16380, LEMSCO-14811, Oct. 1980. NTIS: 82N19631.
- 2-19. A Summary of Observations Concerning the Information in the Spectral Temporal-Ancillary Data Available for Estimating Ground Cover Crop Proportions. FC-J0-00486, JSC-16815, Feb. 1981. NTIS: 81N33572.
- 2-20. Segment-Level Evaluation of the Simulated Aggregation Test: U.S. Corn and Soybean Exploratory Experiment. FC-L0-00493, JSC-16820, LEMSCO-15116, Oct. 1980. NTIS: 82N19636.

Reports

- 2-21. A Description of the Reformatted Spring Small Grains Labeling Procedure Used in Test 2, Part 2, of the U.S./Canada Wheat and Barley Exploratory Experiment. FC-L0-04000, JSC-16827, LEMSCO-15404, Feb. 1981. NTIS: 81N31597.
- 2-22. Semi-Annual Project Management Report Program Review Presentation to Level 1, Interagency Coordination Committee. FC-J0-04010, JSC-16835, Nov. 6, 1980. NTIS: 81N21417.
- 2-23. Weather Analysis and Interpretation Procedures Developed for the U.S./Canada Wheat and Barley Exploratory Experiment. FC-L0-04014, JSC-16840, LEMSCO-15612, Nov. 1980. NTIS: 81N31599.
- 2-24. Selection of U.S.S.R. Foreign Similarity Region. IT-L0-04020, JSC-16845, LEMSCO-15643, Jan. 1982. NTIS: 82N24531.
- 2-25. Identification of U.S.S.R. Indicator Regions. FC-L0-04027, JSC-16847, LEMSCO-15118, Sept. 1980. NTIS: 81N21419.
- 2-26. Evaluation of Spring Wheat and Barley Crop Calendar Models for the 1979 Crop Year. FC-L1-04030, JSC-16850, LEMSCO-15936, Feb. 1981. NTIS: 81N29508.
- 2-27. Interim Catalog Ground Data Summary Data Acquisition Year 1979. MU-L1-04055, JSC-17119, LEMSCO-16207, Feb. 1981. NTIS: 82N19608.
- 2-28. Interim Catalog Ground Data Summary Data Acquisition Year 1978. MU-L1-04056, JSC-17120, LEMSCO-16325, Mar. 1981. NTIS: 81N33546.
- 2-29. U.S. Corn and Soybeans Exploratory Experiment Summary Report. FC-L1-04073, JSC-17129, Mar. 1981. NTIS: 82N21640.
- 2-30. Semi-Annual Project Management Report - Program Review Presentation to Level 1. FC-J1-04087, JSC-17134, Apr. 1981.
- 2-31. Sampling and Aggregation Components Software and Module Descriptions. FC-L1-04093, JSC-17136, LEMSCO-16221, Dec. 1981. NTIS: 82X74796.
- 2-32. 1980 U.S. Corn and Soybeans Exploratory Experiment Final Report. FC-L1-04096, JSC-17138, LEMSCO-16573, Oct. 1981. NTIS: 82N23579.
- 2-33. Country Summary Report - Australia. FC-L1-04097, JSC-17140, LEMSCO-16645, May 1981. NTIS: 82N22594.
- 2-34. Preliminary Catalog: Ground Data Summary Data Acquisition for 1980. MU-L1-04100, JSC-17365, May 1981.
- 2-35. Enumerator's Manual, 1981 Ground Data Survey. FC-J1-04108, JSC-16860, Jan. 1981. NTIS: 82N21653.
- 2-36. Fiscal Year 1981 U.S. Corn and Soybeans Pilot Experiment Plan, Phase I. FC-L1-04109, JSC-17151, LEMSCO-16575, Dec. 1981. NTIS: 82N24541.
- 2-37. FCPF Quarterly Review. FC-J1-04117, Mar. 1981.
- 2-38. Sample Selection in Foreign Similarity Regions for Multicrop Experiment. FC-L1-04120, JSC-17401, LEMSCO-16663, Aug. 1981. NTIS: 82N21655.
- 2-39. Evaluation of a Segment-Based Landsat Full-Frame Approach to Crop Area Estimation. FC-P1-04121, NAS 9-15466, June 1981. NTIS: 82N20590.
- 2-40. Interim Catalog, Ground Data Summary Data Acquisition Year 1977. MU-L1-04123, JSC-17403, LEMSCO-16938, July 1981. NTIS: 82X74788.
- 2-41. 1980 U.S./Canada Wheat and Barley Exploratory Experiment - Summary Report. FC-L1-04127, JSC-17406, LEMSCO-16921, July 1981. NTIS: 82N23565.
- 2-42. Enumerator's Manual for Australia - 1981 Ground Data Survey. FC-J1-04130, JSC-17411, Aug. 1981.
- 2-43. Selection of Argentine Indicator Region. IT-L1-04132, JSC-17408, LEMSCO-16874, Mar. 1981. NTIS: 82N24549.
- 2-44. Selection of the Australia Indicator Region. FC-L1-04145, JSC-17421, LEMSCO-15682, Sept. 1981. NTIS: 82N23595.
- 2-45. Analysis of Scanner Data for Crop Inventories - Period Covered November 15, 1979 - February 15, 1980. MU-E1-04161, NAS 9-15476, May 1980.
- 2-46. Analysis of Scanner Data for Crop Inventories - Period Covered February 16, 1980 - May 15, 1980. MU-E1-04162, NAS 9-15476, May 1980.
- 2-47. Description of Historical Crop Calendar Data Base Developed to Support FCPF Project Experiment. FC-L1-04142, JSC-17417, LEMSCO-16929, Oct. 1981. NTIS: 82N23582.
- 2-48. Development of Rotation Sample Designs for the Estimation of Crop Acreages. FC-L1-04155, JSC-17427, LEMSCO-15409, Sept. 1981. NTIS: 82N21654.
- 2-49. Normal Crop Calendars Volume III: The Corn and Soybean States of Illinois, Indiana, and Idaho. FC-L1-04172, JSC-17432, LEMSCO-16944, Oct. 1981. NTIS: 82N23594.
- 2-50. Preliminary Technical Results Review of FY81 Experiments, Vols. I and II. FC-J1-04175, JSC-17433, Sept. 1981. NTIS: 82N22591.
- 2-51. A Gradient Model of Vegetation and Climate Utilizing NOAA Satellite Imagery Phase I: Texas Transect. FC-J1-04176, JSC-17435, Aug. 1981. NTIS: 82N21648.
- 2-52. Semi-Annual Project Management Report - Program Review Presentation to Level 1 Interagency Coordination Committee. FC-J1-04181, JSC-17438, Nov. 1981. NTIS: 82N23604.
- 2-53. Application of Thermal Model for Pan Evaporation to the Hydrology of a Defined Medium, the Sponge. FC-L1-04192, JSC-17440, LEMSCO-16935, Nov. 1981. NTIS: 82N23590.
- 2-54. Determination of the Optimal Level for NAS Combining Area and Yield Estimates, FC-P1-04197, JSC-15466, Oct. 1981. NTIS: 82N21673.
- 2-55. Information Presented at the Quarterly Project Technical Interchange Meeting, July 9-10, 1981. IT-J1-04199, JSC-17785, Dec. 1981.
- 2-56. Evaluation of the Procedure 1A Component of the 1980 U.S./Canada Wheat and Barley Exploratory Experiment. FC-L1-04219, JSC-17806, LEMSCO-16311, Dec. 1981.
- 2-57. General Multiyear Aggregation Technology: Methodology and Software Documentation. IT-L2-04228, JSC-17814, LEMSCO-17153, March 1982.
- 2-58. Evaluation of the U.S./Canada Wheat and Barley Exploratory Experiment Shakedown Test Analyst Labeling Results. FC-L2-04229, JSC-17815, LEMSCO-16633, Dec. 1981. NTIS: 82N24556.
- 2-59. Augmentation of Landsat MSS Data by SEASAT-SAR for Agricultural Application. IT-E2-04233, NAS 9-16538, April 1982.

2-60. Association of Spectral Development Patterns with Development Stages of Corn. IT-E2-04235, NAS 9-16538, Feb. 1982.

2-61. Estimating Acreage by Double-Sampling Using Landsat Data. IT-E2-04246, NAS 9-15476, Jan. 1982.

2-62. Incorporating Partially Identified Sample Segments into Acreage Estimation Procedures: Estimates Using Only Observations from the Current Year. FC-T2-04261, Dec. 1981.

2-63. Presentation of Information of the Inventory Technology Development Project Quarterly Technical Interchange Meeting, March 24-25, 1982. IT-J2-04262, JSC-17828, Apr. 1982. NTIS: 82N77634.

2-64. Semi-Annual Program Review Presentation to Level 1, Interagency Coordination Committee. IT-J2-04267, JSC-17830, Apr. 1982.

2-65. Research in Satellite-Aided Crop Inventory and Monitoring. IT-J2-04282, JSC-18231, Apr. 1982.

2-66. Shuttle Imaging Radar (SIR-A) An Agricultural Analysis. IT-J2-04283, JSC-18232, March 1982.

2-67. Research Advances in Satellite-Aided Crop Forecasting. IT-J2-04296, JSC-18239, Sept. 1982.

2-68. Research in Satellite-Aided Crop Forecasting. IT-J2-04297, JSC-18240, May 1982.

2-69. Software for the Grouped Optimal Aggregation Technique. IT-L2-04304, JSC-18244, LEMSCO-17755, Feb. 1982.

2-70. Analysis of the Profile Characteristics of Corn and Soybean Using Field Reflectance Data. IT-E2-04310, NAS 9-16538, June 1982.

2-71. Development, Implementation and Evaluation of Satellite-Aided Agricultural Monitoring System - Semi-Annual Report. IT-E2-04311, NAS 9-16538, June 1982.

2-72. Missing Observations in Multiyear Rotation Sampling Designs. IT-T2-04323, NAS 9-14689, Dec. 1981.

2-73. Construction of a Remotely Sensed Area Sampling Frame for Southern Brazil. IT-U2-04332, AGES No. 820526, June 1982.

2-74. Thematic Mapper Performance Assess. in Renewable Resources/Agricultural Remote Sensing - Initial Scene Quick-Look Analysis. IT-J2-04369, JSC-18579, Sept. 15, 1982.

2-75. Research and Development of Landsat-Based Crop Inventory Techniques. IT-E2-04226, NAS 9-15476, Jan. 1982.

2-76. Final Report: Development, Implementation and Evaluation of Satellite-Aided Agricultural Monitoring System. IT-E2-04377, NAS 9-16538, Nov. 1982.

2-77. Semi-Annual Program Review Presentation to Level 1, Interagency Coordination Committee. IT-J2-04378, JSC-18582, Nov. 29, 1982.

2-78. Summary Report: Australia Ground Data Collection 1981-82 Crop Year, Vols. 1 and 2. IT-L2-04381, JSC-18584, LEMSCO-18650, Dec. 1982.

2-79. Technical Summary of Accomplishments Made in Preparation for the USSR Barley Exploratory Experiment. IT-L2-04386, JSC-18588, LEMSCO-17763, Dec. 1982.

2-80. A Nonparametric Technique Which Estimates Both the Number of Clusters and the Assignment of Observations to Clusters. IT-L3-04390, JSC-18592, LEMSCO-18387, Jan. 1983.

2-81. Area Estimation Using Multiyear Designs and Partial Crop Identification Final Report. IT-T3-04395, NAS 9-13894, Jan. 1983.

2-82. The 1980 U.S./Canada Wheat and Barley Exploratory Experiment Final Report - Volumes I and II. IT-L3-04398, JSC-18602, LEMSCO-18629, Apr. 1983.

Minutes

2-83. Minutes of the Semi-Annual Formal Project Manager's Review. FC-J0-00501, JSC-16356, Feb. 13, 1980.

2-84. Minutes of the Semi-Annual Formal Project Manager's Review Including Preliminary Technical Review Reports of FY80 Experiments. FC-J0-00502, JSC-16823, Sept. 24, 1980. NTIS: 82N19614.

2-85. Proceedings of the AgRISTARS FCPF Project Quarterly Technical Interchange Meeting. FC-J1-00504, JSC-17787, Sept. 1981. NTIS: 82X75091.

Plans

2-86. U.S./Canada Wheat and Barley Exploratory Labeling Experiment Implementation Plan. FC-J0-00600, JSC-16336, Jan. 1980.

2-87. The Development of a Sampling Strategy for Multicrop Estimation: A Technical Plan. FC-L0-00603, JSC-16005, LEMSCO-13481, Nov. 1979.

2-88. Foreign Commodity Production Forecasting Project Implementation Plan. FC-J0-00604, JSC-16344, Jan. 15, 1980.

2-89. Examination of New Sampling and Aggregation Approaches. FC-B0-00605, NAS 9-14565, Mar. 1980.

2-90. Configuration Management Plan. FC-L0-00608, JSC-16363, LEMSCO-14943, June 1980.

2-91. Supplemental U.S./Canada Wheat and Barley Exploratory Experiment Implementation Plan: Evaluation of a Procedure 1A Technology. FC-L0-00609, JSC-16364, LEMSCO-15042, June 1980. NTIS: 81N12513.

2-92. World Multicrop Test Site Overflights for 1980 Crop Year Implementation Plan. FC-J0-00610, JSC-16365, June 1980.

2-93. U.S./Canada Wheat and Barley Crop Calendar Exploratory Experiment Implementation Plan. FC-J0-00611, JSC-16812, LEMSCO-15323, Sept. 1980. NTIS: 82N15494.

2-94. Fiscal Year 1980-81 Implementation Plan for Development and Integration of Sampling and Aggregation Procedures. FC-L0-00612, JSC-16819, LEMSCO-15168, Mar. 1981. NTIS: 82N15491.

2-95. FCPF Implementation Plan (FY81 & FY82). FC-J0-C0614, JSC-16828, Oct. 1980.

2-96. Fiscal Year 1981-82 U.S./Canada Spring Small Grains Experiment Plan. FC-L1-00633, JSC-17405, LEMSCO-16868, Dec. 1981. NTIS: 82X10190.

2-97. Technical Plan for Developing and Testing a Cloud Cover/Acquisition History Simulator. FC-L1-00634, JSC-17407, LEMSCO-16566, July 1981.

2-98. Technical Plan for Testing the Automated Pixel Screening Procedures. FC-L1-00635, JSC-17409, LEMSCO-16933, Oct. 1981. NTIS: 82X74786.

2-99. Australia Ground Data Collection Detailed Plan for 1981/82 Crop Year. FC-L1-00639, JSC-17607, LEMSCO-17173, Sept. 1981. NTIS: 82X74785.

2-100. FCPF Project Implementation Plan for Fiscal Years 1982 and 1983. FC-J1-00640, JSC-17425, Sept. 30, 1981.

2-101. Inventory Technology Development Plan for Fiscal Year 1983. IT-J2-C0654, JSC-18270, Sept. 30, 1983.

Procedures

2-102. Maximal Analysis Labeling Procedure (Preliminary). FC-L0-00700, JSC-16399, LEMSCO-14080, Feb. 1980. NTIS: 80N30862.

2-103. Enumerator's Manual, 1981 Ground Survey Data, NASA, USDA/ESS. FC-J1-04108, JSC-16860, Washington, D.C., Jan. 1981.

2-104. User's Guide for the U.S. Baseline Corn and Soybean Segment Classification Procedure. FC-E1-00712, NAS 9-15476, Mar. 1981.

2-105. FCPF Project Communications Documentation Standards Manual. FC-L1-00714, JSC-17141, LEMSCO-16850, June 1981. NTIS: 82N21645.

2-106. Volume I: Project Procedures, Designation, and Description Document. FC-L1-00715, JSC-17154, LEMSCO-16852, June 1981. NTIS: 82N22542.

2-107. Volume I: Project Test Reports Document. FC-L1-00718, JSC-17155, LEMSCO-16851, June 1981. NTIS: 82N21639.

2-108. Operator's Manual for the Analyst Handbook for the Augmented U.S. Baseline Corn and Soybean Segment Classification Procedure (CS-1A). IT-E1-00721, NAS 9-15476, Oct. 1981. NTIS: 82X10189.

2-109. Analyst Handbook for the Augmented U.S. Baseline Corn and Soybean Segment Classification Procedure (CS-1A). IT-E1-00723, NAS 9-15476, NAS 9-14565, Oct. 1981. NTIS: 82X74778.

2-110. User's Guide to the CS2 Automated Corn/Soybean Labeling Procedure. IT-J2-00738, JSC-17813, Oct. 1981. NTIS: 82X75093.

2-111. User's Guide to the C/S-2B Corn/Soybean Proportion Estimation Procedure. IT-J2-00742, JSC-18230, Apr. 1982.

2-112. Software Documentation Guidelines. IT-L2-00745, JSC-18248, LEMSCO-18241, May 1982.

2-113. Data Base Configuration Management Guidelines. IT-L2-00746, JSC-18249, LEMSCO-18238, May 1982.

2-114. Software Configuration Management Guidelines. IT-I2-00747, JSC-18250, LEMSCO-18239, May 1982.

2-115. Software Development Guidelines. IT-L2-00748, JSC-18251, LEMSCO-18240, May 1982.

2-116. Development and Description of CAESAR (SSG-3B/C), A Machine-Based Proportion Estimation Procedure. IT-L2-00752, JSC-18263, LEMSCO-17542, Aug. 1982.

2-117. Early Season Task Program Maintenance Manual. IT-L3-00758, JSC-18263, LEMSCO-17542, Aug. 1982.

2-118. Crop Proportion Ground-Truth Simulator (ProSim) and Crop Proportion Estimate Simulator (EstSim): Software Documentation, Technical Description, and User Guide. IT-L3-00763, JSC-18603, LEMSCO-18559, Feb. 1983.

2-119. Baker, T. C., J. H. Smith, and J. T. Malin: Update on a System for Large Area Crop Inventory from Remotely Sensed Data. LARS Eighth Int. Symposium, Sept. 1982.

2-120. Christ, E. P.: Cultural and Environmental Influences on the Temporal-Spectral Development Patterns of Corn and Soybeans. LARS Eighth Int. Symposium, Sept. 1982.

2-121. Cicone, R. C., and M. D. Metzler: Comparison of Landsat MSS, Nimbus 7 CZCS, and NOAA 6/7 AVHRR Features for Land Use Analysis. LARS Eighth Int. Symposium, Sept. 1982.

2-122. Dailey, C. L., and G. M. Chapman: Automated Pixel Screening and Selection. LARS Eighth Int. Symposium, Sept. 1982.

2-123. Dennis, T. B., R. B. Cate, C. V. Nazare, M. M. Smyrski, and T. C. Baker: SSG-4 - An Automated Spring Small Grains Proportion Estimator. LARS Eighth Int. Symposium, Sept. 1982.

2-124. Doraiswamy, P., and D. Thompson: An Agromet Crop Phenology Model for Spring Wheat. American Soc. Agron., Crop Sci. Soc. America, Soil Sci. Soc. America, Nov.-Dec. 1980.

2-125. Hay, C. N.: Remote Sensing Measurement Techniques for Use in Crop Inventories. Remote Sensing for Resource Management Conf. (Kansas City, Mo.), sponsored by Soil Conserv. Soc. America, NASA, USDA, NOAA, USGS, etc., Oct. 1980.

2-126. Hixson, M., S. Davis, and M. Bauer: Evaluation of a Segment-Based Full-Frame Approach to Crop Area Estimation. LARS Seventh Int. Symposium.

2-127. Hixson, M. M., B. J. Davis, and M. E. Bauer: Sampling Landsat Classifications for Crop Area Estimation. Photogrammetric Engineering and Remote Sensing, Vol. 47, No. 9, Sept. 1981, pp. 1343-1348.

2-128. Metzler, M. D., R. C. Cicone, and K. I. Johnson: The Evaluation of a Semi-Automated Procedure for Classifying Corn and Soybeans Without Ground Data. LARS Eighth Int. Symposium, Sept. 1982.

2-129. Mohler, R. R. J., W. F. Palmer, M. M. Smyrski, C. V. Nazare, and T. C. Baker: Development, Test, and Evaluation of a Computerized Procedure for Using Landsat Data to Estimate Spring Small Grains Acreage. LARS Eighth Int. Symposium, Sept. 1982.

2-130. Odenweller, J. B., and K. I. Johnson: Crop Identification Using Landsat Temporal-Spectral Profiles. LARS Eighth Int. Symposium, Sept. 1982.

2-131. Payne, R. W.: Sonora Exploratory Study for the Detection of Wheat-Leaf Rust, Nov. 1980. NTIS: 82N21661.

2-132. Rice, D., M. Metzler, and O. Mykoenka: An Image Processing System. Seventh Int. Symposium on Machine Processing of Remotely Sensed Data, Purdue Univ. (W. Lafayette, Ind.), 1981.

2-133. Smith, J. H., C. C. Lin, M. Dvorin, and J. T. Malin: Acquisition History Simulation for Evaluation of Landsat-Based Crop Inventory Systems. LARS Eighth Int. Symposium, Sept. 1982.

3. YMD

Instructions

3-01. Yield Model Development/Soil Moisture Interface Control Document. MU-J0-00100, JSC-16841, Nov. 1980. NTIS: 82N19629.

3-02. Yield Model Development/Early Warning and Crop Condition Assessment Interface Control Document. MU-J0-00102, JSC-16843, Nov. 1980.

Reports

- 3-03. Evaluation of "Straw Man" Model 1, the Simple Linear Model for Soybean Yields in Iowa, Illinois, and Indiana. YM-11-04095, USDA/ESS Staff, AGESS 810304, Mar. 1981.
- 3-04. Development of a Surface Isolation Estimation Technique Suitable for Application of Polar-Orbiting Satellite Data. YM-N1-04198, Nov. 1981. NTIS: 82N21656.
- 3-05. Estimating Daily Advective Contributions to Potential Evapotranspiration. YM-U2-04245, AGESS 820428, May 1982.
- 3-06. A Model for the Simulation of Growth and Yield in Winter Wheat. YM-U2-04281, JSC-18229, Aug. 1981.
- 3-07. Evaluation of the Williams-Type Spring Wheat Model in North Dakota and Minnesota. YM-U2-04286, JSC-18233, Jan. 1982.
- 3-08. Evaluation of the Williams-Type Model for Barley Yields in North Dakota and Minnesota. YM-U2-04287, JSC-18234, Dec. 1981.
- 3-09. Evaluation of the CEAS Model for Barley Yields in North Dakota and Minnesota. YM-U2-04288, JSC-18235, Dec. 1981.
- 3-10. Comparison of CEAS and Williams-Type Models for Spring Wheat Yields in North Dakota and Minnesota. YM-U2-04289, JSC-18236, Mar. 1982.
- 3-11. Comparison of the CEAS and Williams-Type Barley Yield Models for North Dakota and Minnesota. YM-U2-04290, JSC-18237, Mar. 1982.
- 3-12. Second Generation Crop Yield Models Review. YM-12-04306, JSC-18245, Mar. 1982.
- 3-13. Crop Weather Models of Barley and Spring Wheat Yield for Agrophysical Units in North Dakota. YM-12-04321, June 1982.
- 3-14. Crop weather Models of Corn and Soybeans for APU/s in Iowa Using Monthly Met Predictors. YM-12-04348, Sept. 1982.
- 3-15. Evaluation of the CEAS Trend and Monthly Weather Data Models for Soybean Yields in Iowa, Illinois, and Indiana. YM-12-04364, JSC-18575, Oct. 1982.
- 3-16. Evaluation of Thompson-Type Trend and Monthly Weather Data Models for Corn Yields in Iowa, Illinois, and Indiana. YM-12-04365, JSC-18576, Oct. 1982.
- 3-17. One, Two, and Three Line Segment "Straw Man" Models. Soybean Yields in Iowa, Illinois, and Indiana. AGESS 810514, YMD-1-3-2, 81-05.1, May 1981.
- 3-18. Winter Wheat: A model for the Simulation of Growth and Yield in Winter Wheat. YM-U2-04281, JSC-18229, Aug. 1981.
- 3-19. Grain Production in the USSR, Present Situation, Perspectives for Development and Methods for Production. AGESS 810904, YMD-2-1 81-08.1, Sept. 1981.
- 3-20. A Comparison of Measured and Estimated Meteorological Data for Use in Crop Growth Modeling. YM-J2-04359, JSC-18573, Sept. 1982.
- 3-21. Comparison of CRD, APU, and State Models for Iowa Corn and Soybeans and North Dakota Barley and Spring Wheat. YM-13-04419, May 1983.

Plans

- 3-22. Yield Model Development Implementation Plan. YM-J0-C0616, JSC-16851, 1980.
- 3-23. Yield Model Development Implementation Plan. YM-J1-C0618, JSC-16857, 1981. NTIS: 81N32577.
- 3-24. Yield Model Development Project Implementation Plan for FY82 and FY83. YM-J1-C0642, JSC-17436.
- 3-25. Yield Model Development Project Implementation Plan. YM-U2-C0655, JSC-18564, Sept. 1982.

Procedures

- 3-26. Gridded Meteorological Data Extraction System (GMDES) User's Guide. YM-L2-00736, JSC-17808, LEMSCO-17642, Nov. 1981.
- 3-27. Extraction Procedures and Requirements for Gridded Air Force Meteorological Data. YM-U2-00737, JSC-17811, Feb. 1982.
- 3-28. User's Appraisal of Yield Model Evaluation Criteria. YM-U2-00740, JSC-18228, Mar. 1982.
- 3-29. Procedures and Requirements for Evaluation of U.S. Air Force AGROMET Data. YM-U2-00739, JSC-17819, Mar. 1982.
- 3-30. Document Publication Procedure. YM-J1-00710, JSC-16856. Feb. 1981.

Presentations

- 3-31. French, V.: Alternative Techniques in Modeling Grain Yield for Large Areas Using Monthly Meteorological Data from Eastern Europe. Sixteenth Conference on Agric. and Forest Meteor., Apr. 1983.
- 3-32. French, V., and S. LeDuc: Strategies for Determining Climatic Groupings. Eighth Conf. on Probability and Statistics in Atmospheric Sci., Nov. 1983.
- 3-33. French, V., J. Sebaugh, and S. LeDuc: Cluster Analysis: Identifying Years or Areas with Similar Crop Response. Meeting of American Soc. of Agric. Eng., Dec. 1982.
- 3-34. Hodges, T., V. French, and S. LeDuc: Estimating Solar Radiation for Plant Simulation Models. Sixth Annual Workshop of the Biological Systems Group, Univ. of Ill., Mar. 29-31, 1983.
- 3-35. Soyphen: A Soybean Phenology Model. Sixteenth Conference on Agric. and Forest Meteorology (Fort Collins, Colo.), April 25-29, 1983.
- 3-36. Van Dyke, A., S. LeDuc, C. Sakamoto, and D. McCrary: Potential Products for Polar Stereographic AVHRR Data. AgRISTARS Technical Interchange for Topics on AVHRR, June 20-22, 1983.

Unnumbered Documents

- 3-37. Aase, J. K., and F. H. Siddoway: Assessing Winter Wheat Dry Matter Production via Spectral Reflectance Measurements. Remote Sensing of Environment (in press).
- 3-38. Aase, J. K., and F. H. Siddoway: Crown-Depth Soil Temperatures and Winter Projection for Winter Wheat Survival. Soil Sci. Soc. America J. vol. 43, 1979, pp. 1229-1233.

- 3-39. Aase, J. K., and F. H. Siddoway: Determining Winter Wheat Stand Densities Using Spectral Reflectance Measurements. *Agron. J.*, vol. 72, 1980, pp. 139-152.
- 3-40. Aase, J. K., and F. H. Siddoway: Microclimate of Winter Wheat Grown in Three Standing Stubble Heights. Tillage Symposium, North Dakota State Univ. (Fargo) (accepted May 30, 1980.)
- 3-41. Aase, J. K., and F. H. Siddoway: Spring Wheat Yield Estimates From Spectral Reflectance Measurements. *IEEE Trans. Geoscience and Remote Sensing* (in press).
- 3-42. Aase, J. K., and F. H. Siddoway: Stubble Height Effects on Seasonal Microclimate, Water Balance, and Plant Development of No-Till Winter Wheat. *Agric. Meteorol.*, vol. 21, 1980, pp. 1-20.
- 3-43. Acock, B., F. D. Whisler, J. M. McKinion, S. B. Turner, and D. N. Baker: GLYCIM - A Model Simulating Growth and Yield in Soybean. Fortran Code. 1980.
- 3-44. Acock, B., D. N. Baker, V. R. Reddy, J. M. McKinion, F. D. Whisler, D. Del Castillo, and H. F. Hodges: Soybean Response to Carbon Dioxide: Measurement and Simulation. 1981 Report #4 in series Response of Vegetation to Carbon Dioxide. Joint Program of the U.S. Dept. of Energy and the U.S. Dept. of Agriculture, 1982.
- 3-45. Acock, B., D. N. Baker, V. R. Reddy, J. M. McKinion, F. D. Whisler, D. Del Castillo, H. F. Hodges: Response of Vegetation to Carbon Dioxide, 008. Soybean Response to Carbon Dioxide: Measurement and Simulation. 1982 Progress report. Joint program of the U.S. Dept. of Energy, Carbon Dioxide Research Division, and the U.S. Dept. of Agriculture, Agricultural Res. Service, Miss. State Univ., 1983.
- 3-46. Acock, B., V. R. Reddy, F. G. Whisler, D. N. Baker, J. M. McKinion, H. F. Hodges, and K. J. Boote: The Soybean Crop Simulation GLYCIM. Report #2 in series Response of Vegetation to Carbon Dioxide. Joint program of the U.S. Dept. of Energy and the U.S. Dept. of Agriculture, 1982.
- 3-47. Acock, B., V. R. Reddy, F. D. Whisler, D. N. Baker, J. M. McKinion, H. F. Hodges, and K. J. Boote: The Soybean Crop Simulator GLYCIM. Report in series Response of Vegetation to Carbon Dioxide. Joint program of the U.S. Dept. of Energy and the U.S. Dept. of Agriculture, 1983.
- 3-48. Baker, D. N.: Plant Growth Modeling. *Agric. Eng.*, vol. 62, no. 9, 1981, pp. 17-18.
- 3-49. Baker, D. N.: Simulation for Research and Crop Management. (F. T. Corbin, ed.) *Proc. World Soybean Res. Conf. II* (Raleigh, N.C.), Mar. 26-29, 1980, pp. 533-546.
- 3-50. Baker, D. N., and J. R. Lambert: The Analysis of Crop Responses to Enhanced Atmospheric CO₂ Levels. In Report of the Workshop on Environmental and Societal Consequences of a Possible CO₂ Induced Climate Change. American Assoc. Advance. Sci. Meeting (Annapolis, Md.), 1980, pp. 275-294.
- 3-51. Baker, D. N., B. Acock, H. Z. Enoch: The Effects of CO₂ on Plant Stress. *Cotton Physiology - A Treatise* (J. R. Mauney and M. P. Stewart, eds.), AAAS Panel 3 Report, 1982.
- 3-52. Baker, D. N., L. H. Allen, Jr., and J. R. Lambert: Effects of Increased CO₂ on Photosynthesis and Agricultural Productivity. A commissioned paper for AAAS-DOE Proj. - Environmental and Societal Consequences of a CO₂ Induced Climate Change, 1981.
- 3-53. Baker, D. N., H. Z. Enoch, and B. Acock: Whole Plant Growth and Development. CO₂ and Plants: The Response of Plants to Rising Levels of Atmospheric Carbon Dioxide (E. R. Lemon, ed.), 1982, pp. 107-130.
- 3-54. Baker, D. N., H. Z. Enoch, B. Acock, et al.: Plant Growth and Development. (E. R. Lemon, ed.) AAAS Panel 3 Report, 1982.
- 3-55. Baker, D. N., J. A. Landivar, and J. R. Lambert: Model Simulation of Fruiting. *Proc. Cotton Prod. Res. Conf.* (Phoenix, Ariz.), Jan. 7-12, 1979, pp. 261-264.
- 3-56. Baker, D. N., J. A. Landivar, F. D. Whisler, and V. R. Reddy: Plant Responses to Environmental Conditions and Modeling Plant Development. (W. L. Decker, ed.) *Proc. Weather and Agric. Symposium*, 1981, pp. 69-135.
- 3-57. Baligar, V. C., V. E. Nash, F. D. Whisler, and D. L. Myhre: Sorghum and Soybean Growth as Influenced by Synthetic Pans. *Commun. in Soil Sci. and Plant Analysis*, vol. 12, 1981, pp. 97-107.
- 3-58. Bar-Yosef, B., J. R. Lambert, and D. N. Baker: RHIZOS: A Simulation of Root Growth and Soil Processes: III. Sensitivity Analysis and Validation, *ASAE J.*, vol. 25, 1982, pp. 1268-1273, 1281.
- 3-59. Barnett, T. L., and D. R. Thompson: Large-Area Relation of Landsat MSS and NOAA-6 AVHRR Spectral Data to Wheat Yield. *Remote Sensing of Environment*, vol. 13, 1983, pp. 277-290.
- 3-60. Barnett, T. L., and D. R. Thompson: The Use of Large-Area Spectral Data in Wheat Yield Estimation. *Remote Sensing of Environment*, vol. 12, 1982, pp. 509-518.
- 3-61. Barnett, T. L., S. LeDuc, and F. Warren: Criteria for Identifying Candidate Yield Models. 1980.
- 3-62. Barnett, Thomas L., Clarence M. Sakamoto, and Wendell W. Wilson: Identification of Candidate Yield Models for Testing and Evaluation in Support of FY81 Domestic Pilot Tests. YMD-1-2-9, 80-8.1, 1980.
- 3-63. Bauer, A.: Responses of Tall and Semidwarf Hard Red Spring Wheats to Fertilizer Nitrogen Rates and Water Supply in North Dakota, 1969-1974. *Bull. 510*, North Dakota Agric. Exp. Station, 1980.
- 3-64. Belford, R. K., R. W. Rickman, B. Klepper, and R. R. Allmaras: A New Technique for Sampling Intact Shoot-Root Systems of Field-Grown Cereal Plants. *Agron. Abstr.*, 1982, p. 11.
- 3-65. Bhattacharyay, B. N.: Crop Yield Model Test and Evaluation, a Statistical Approach. Dept. of Statistics, Univ. of Mo. (Columbia), 1980.
- 3-66. Bigsby, F., and J. L. Sebaugh: Evaluation of Haun Models for Predicting Spring Wheat Yields in North Dakota. USDA/SRS/SRD, AGESS 83112, YMD 1-4-1, 83-11.1, Nov. 1983.
- 3-67. Cassel, D. K., L. F. Ratliff, and J. T. Ritchie: Models for Estimating Potential In Situ Plant Extractable Water Using Soil Physical and Chemical Properties. *Soil Sci. Soc. America Proc.*, vol. 47, 1983, pp. 764-769.

- 3-68. Cotter, J. J., and J. L. Sebaugh: An Evaluation of the Sources, Accuracy, and Availability of the Input Data Required to Run Feyerherm's Winter Wheat Model and Preliminary Testing Performed by Dr. Feyerherm. Oct. 1982.
- 3-69. Crampton, C. R., B. L. Klepper, and R. W. Rickman: Winter Wheat Trials, A Case Study Using Degree Days. 1983 Research Report - Columbia Basin Agric. Res. Spec. Rep. 680, Oregon Agric. Exp. Sta. (Corvallis), 1983, pp. 37-42.
- 3-70. Del Castillo, D., F. D. Whisler, B. Acock, and D. N. Baker: The Effect of High Atmospheric Carbon Dioxide Concentration on Root Growth of Soybean and Wheat. Southern Regional Plant Root Environment Work Group (Lubbock, Tex.), July 13-14, 1982.
- 3-71. Denison, R. F.: A Nondestructive Field Assay for Nitrogen Fixation (Acetylene Reduction). M.S. Thesis, Cornell Univ., 1980.
- 3-72. Doering, E. J., and W. O. Willis: Effect of Soil-Solution Concentration on Cation-Exchange Relations. In ISSS Int. Printers (New Delhi, India), 1980, pp. 129-133.
- 3-73. Douglas, C. L., Jr.: Silicic Acid and Oxidizable Carbon Movement in a Walla Walla Silt Loam As Related to Long-Term Residue and Nitrogen Applications. Ph. D. Dissertation, Ore. State Univ., 1983.
- 3-74. Douglas, C. L., Jr.: Temperature and Moisture Effects on Decomposition of Wheat Straws With Different N and S Contents. In 1980 Research Report - Columbia Basin Agric. Res. Spec. Rep. 571, Oregon Agric. Exp. Station (Corvallis), 1980, pp. 68-72.
- 3-75. Douglas, C. L., Jr., R. R. Allmaras, and N. C. Roager, Jr.: Silicic Acid and Oxidizable Carbon Movement in a Walla Walla Silt Loam as Related to Long-Term Management. Soil Sci. Soc. America J., vol. 48, 1984.
- 3-76. Douglas, C. L., Jr., R. R. Allmaras, P. E. Rasmussen, R. E. Ramig, and N. C. Roager, Jr.: Wheat Straw Composition and Placement Effects on Decomposition in Dryland Agriculture of the Pacific Northwest. Soil Sci. Soc. America J., vol. 44, 1980, pp. 833-837.
- 3-77. Douglas, C. L., Jr., R. R. Allmaras, P. E. Rasmussen, R. W. Rickman, and D. E. Wilkins: Crop Residue Management in Conservation Tillage Systems. Solutions to Environmental and Economic Problems of the Pacific Northwest (STEEP), 1983, pp. 134-135.
- 3-78. Dregne, H. E., and W. O. Willis, eds.: Dryland Agriculture. American Soc. Agron. Monograph, no. 23., 1983.
- 3-79. Fisher, G., K. Pike, R. Rickman, and D. Maxwell: The Hessian Fly in Oregon. Ore. State Univ. Ext. Circular 1093, 1981.
- 3-80. Fye, R. E., V. R. Reddy, and D. N. Baker: Cotton Plants: A Preliminary GOSSYM Model. USDA-ARS technical bulletin, AAT-W-18, Aug., 1981.
- 3-81. Goe, D., and W. L. Decker: Documentation on Data Files and Developmental Technical for Computation of County Averages of Temperature and Rainfall. Dept. of Atmospheric Science, Univ. of Mo. (Columbia), Apr. 1983.
- 3-82. Hodges, H. F., F. D. Whisler, N. W. Buehring, R. E. Coats, J. McMillian, N. D. Edwards, and C. Hovermale: The Effect of Planting Date, Row Spacing and Variety on Soybean Yield in Mississippi. Miss. Agric. and Forestry Exp. Sta. Bull., no. 912, 1983.
- 3-83. Idso, S. B., R. D. Jackson, P. J. Pinter, Jr., R. J. Reginato, and J. L. Hatfield: Normalizing the Stress-Degree-Day Parameter for Environmental Variability. Agric. Meteorol. (in press).
- 3-84. Idso, S. B., R. J. Reginato, J. L. Hatfield, G. K. Walker, R. D. Jackson, and P. J. Pinter, Jr.: A Generalization of the Stress-Degree-Day Concept of Yield Prediction to Accommodate a Diversity of Crops. Agric. Meteorol., vol. 21, 1980, pp. 205-211.
- 3-85. Jackson, R. D., P. J. Pinter, Jr., R. J. Reginato, and S. B. Idso: Handheld Radiometry. Agric. Reviews and Manuals - W-19. USDA, SEA-AR Western Region Publ., 1980.
- 3-86. Jodari-Karimi, F., V. H. Watson, H. F. Hodges, and F. D. Whisler: Root Distribution of Water Use Efficiency of Alfalfa As Influenced by Depth of Irrigation. Agron. J., vol. 75, 1983, pp. 1207-1211.
- 3-87. Jones, C. A.: A Review of Evapotranspiration Studies in Irrigated Sugarcane. Hawaiian Planter's Record, vol. 59, 1980, pp. 195-214.
- 3-88. Jones, C. A., and A. Carabaly: Estimation of Leaf Water Potential in Tropical Grasses With a Campbell-Brewster Hydraulic Press. Trop. Agric., Trinidad, vol. 57, 1980, pp. 305-307.
- 3-89. Jones, C. A., D. Pena, and A. Carabaly: The Effects of Plant Water Potential, Leaf Diffusive Resistance, Rooting Density, and Water Use on the Dry Matter Production of Several Tropical Grasses During Short Periods of Drought Stress. Trop. Agric., Trinidad, vol. 57, 1980, pp. 211-221.
- 3-90. Jung, Y.: Water Uptake and Transport of Soybeans as a Function of Rooting Patterns. Ph. D. Dissertation, Iowa State Univ., 1980.
- 3-91. Kanemasu, E. T., and J. T. Ritchie: Minimizing Stress in Crop Production: Climate and Weather. J. Nat. Fert. Assoc. Solutions, vol. 24, no. 6, 1980, pp. 98-104.
- 3-92. Kestle, R. A.: Evaluation of the CEAS Trend and Monthly Weather Data Models for Corn Yields in Iowa, Illinois, and Indiana. Oct. 1982.
- 3-93. Kestle, R. A.: Evaluation of the Thompson-Type Yield Models for Soybeans in Iowa, Illinois, and Indiana. July 1982.
- 3-94. Kestle, R. A.: Analysis of Crop Yield Trends and Development of Simple Corn and Soybean "Straw Man" Models for Indiana, Illinois, and Iowa. YMD-2-11-1, 80-11.1, 1981.
- 3-95. Kestle, R. A. and J. L. Sebaugh: A Review of the Sources, Accuracy and Availability of the Input Data Required to Run Feyerherm's Spring Wheat Model and Preliminary Testing Performed by Feyerherm. Sept. 1981.
- 3-96. Kimes, D. S., B. L. Markham, C. J. Tucker, and J. E. McMurtrey III: Temporal Relationships Between Spectral Response and Agronomic Variables of a Corn Canopy. Remote Sensing of Environment (submitted Aug. 1980).
- 3-97. Kiniry, J. R., J. T. Ritchie, and R. L. Musser: Dynamic Nature of the Photoperiod Sensitive Interval in Maize. Agron. J., vol. 75, 1983, pp. 700-703.
- 3-98. Kiniry, J. R., J. T. Ritchie, R. L. Musser, E. P. Flint, and W. C. Iwig: The Photoperiod Sensitive Interval in Maize. Agron. J., vol. 75, 1983, pp. 687-690.

- 3-99. Klepper, B.: Axial Resistances to Flow in Root Systems. Efficient Water Use in Crop Production, American Soc. Agron. Monograph (in press).
- 3-100. Klepper, B., and R. W. Rickman: Competition Among Tillers in Winter Wheat. The Wheat Grower, vol. 3, no. 2, 1980, p. 53.
- 3-101. Klepper, B., and R. W. Rickman: Growth Rates of Wheat Seedlings From Whole and Cut Grain. Plant Physiol. Suppl., vol. 67, 1981, p. 39.
- 3-102. Klepper, B., R. K. Belford, and R. W. Rickman: The Phenology of Root Development in Winter Wheat. Agron. Abstr., 1982, p. 16.
- 3-103. Klepper, B., Paul E. Rasmussen, and Ron W. Rickman: Fertilizer Placement for Cereal Root Access. J. Soil Water Cons., vol. 38, 1983, pp. 250-252.
- 3-104. Klepper, B., R. W. Rickman, and R. K. Belford: Leaf and Tiller Identification on Wheat Plants. Crop Sci., vol. 23, 1983, pp. 1002-1004.
- 3-105. Klepper, B., R. W. Rickman, and C. M. Peterson: Quantitative Characterization of Seedling Development in Small Cereal Grains. Agron. Abstr., 1981, p. 107.
- 3-106. Klepper, B., R. W. Rickman, and C. M. Peterson: Quantitative Characterization of Seedling Development in Small Cereal Grains. Agron. J., vol. 74, 1982, pp. 789-792.
- 3-107. Klepper, B., R. W. Rickman, and C. M. Peterson: Relationships Between Leaf and Tiller Production in Stephens' Winter Wheat. Plant Physiol. Suppl., vol. 65, 1980, p. 133.
- 3-108. Klepper, B., R. W. Rickman, and C. M. Peterson: The Wheat Plant. Mid-Columbia Cereals Conf. Proc., Feb. 5, 1980. (T. N. Zinn, ed.) The Dalles, Oregon, 1980, pp. 1-8.
- 3-109. Klepper, B., R. W. Rickman, and H. M. Taylor: Farm Management and the Function of Field Crop Root Systems. Agric. Water Mgt. vol. 7, 1983, pp. 115-141.
- 3-110. Klepper, B., T. W. Tucker, and B. D. Dunbar: A Numerical Index to Assess Early Inflorescence Development in Wheat. Crop Sci., vol. 23, 1983, pp. 206-208.
- 3-111. Klepper, B., R. W. Rickman, R. K. Belford, and G. E. Fischbacher: Tiller and Root Development of Wheat Plants. 1982 Research Report - Columbia Basin Agric. Res. Spec. Rep. 661, Oregon Agric. Exp. Sta. (Corvallis), 1982, pp. 8-12.
- 3-112. Kogan, F. N.: Approach to Estimating Climate Fluctuation in Relation to Agriculture. 1983.
- 3-113. Kogan, F. N.: Cumulative Weather Index and Its Application in Assessing Climate Fluctuation Impact on Cereal Yields. 1983.
- 3-114. Environment-Crop Yield Models and Consideration for Their Utilization. 1983.
- 3-115. Kogan, F. N.: Geographical Aspects of Climate and Weather Limitations for Cereal Production in the USSR. 1981.
- 3-116. Kogan, F. N.: Grain Production in the USSR: Present Situation, Perspectives for Development and Methods for Prediction. Sept. 1981.
- 3-117. Kogan, F. N.: Large Area USSR Barley Yield Models: Development and Evaluation. Feb. 1983.
- 3-118. Landivar, J. A., D. N. Baker, and J. N. Jenkins: The Application of GOSSYM in Genetic Feasibility Studies, II: System Analysis of Fruit Abscission and Yield in Okra-Leaf Cultivars. Proc. Beltwide Cotton Prod. Res. Conf. (St. Louis, Mo.), 1980.
- 3-119. Landivar, J. A., D. N. Baker, and J. N. Jenkins: The Application of GOSSYM in Genetic Feasibility Studies, II: Systems Analysis of Increasing Photosynthesis in Cotton Cultivars. Crop Sci., vol. 23, 1983, pp. 504-510.
- 3-120. Landivar, J. A., D. N. Baker, and J. N. Jenkins: The Application of the Cotton Simulation Model GOSSYM in Genetic Feasibility Studies. Crop Sci., vol. 23, 1983, pp. 497-504.
- 3-121. Leamer, R. W., J. R. Noriega, and A. H. Gerbermann: Reflectance of Wheat Cultivars as Related to Physiological Growth Stages. Agron. J., vol. 72, 1980, pp. 1029-1032.
- 3-122. LeDuc, S. K.: Corn Models for Iowa, Illinois, and Indiana. CEAS (Columbia, Mo.), 1980.
- 3-123. LeDuc S.: Spring Wheat Models for North Dakota and Minnesota. 1981.
- 3-124. LeMaster, E. W., J. E. Change, and C. L. Wiegand: A Seasonal Verification of the Suits Spectral Reflectance Model for Wheat. Photogrammetric Eng. and Remote Sensing, vol. 46, no. 1, 1980, pp. 107-114.
- 3-125. Lemon, E. R., and R. VanHoutte: Ammonia Exchange at the Land Surface. Agron. J., vol. 72, 1980, pp. 876-883.
- 3-126. Lugg, D. G., and T. R. Sinclair: Seasonal Change in Morphology and Anatomy of Field-Grown Soybean Leaves. Crop Sci., vol. 20, 1980, pp. 191-196.
- 3-127. Mann, J. E., G. L. Curry, D. W. DeMichele, and D. N. Baker: Light Penetration in a Row-Crop With Random Plant Spacing. Agron. J., vol. 72, 1980, pp. 131-142.
- 3-128. Marani, A., and D. N. Baker: Development of a Predictive Dynamic Simulation Model of Growth and Yield in Acala Cotton. U.S.-Israel Binational Science Foundation Proposal, no. 1708/78 final report, 1981.
- 3-129. Markham, B. L., D. S. Kimes, C. J. Tucker, and J. E. McMurtrey III: The Relationship of Temporal Spectral Response of a Corn Canopy to Grain Yield and Final Dry Matter Accumulation. NASA Tech. Memo. (submitted Nov. 1980).
- 3-130. Mason, W., et al.: Soybean Row Spacing and Soil Water Supply: Their Effects on Growth, Development, Water Relationship, and Mineral Uptake. Publ. AAT-NC-5, USDA, SEA-AR North Central Region, 1980.
- 3-131. McDonald, R. A., E. J. Cooter, A. Eddy: Develop a Daily Climatological Surface Data Base for Multiple Users. Final Report to NOAA/NESDIS/AISC on contract NA 82AA-D-00005, June 1983.
- 3-132. McKinion, J. M.: Dynamic Simulation: A Positive Feedback Mechanism for Experimental Research in Biological Science. Agric. Systems, vol. 5, 1980, pp. 239-250.
- 3-133. McKinion, J. M., and D. N. Baker: Dynamic Crop Simulation: A Synergism of Computers, Experimental Research and the Scientific Method. Proc. Third Int. Conf. on State-of-the-Art of Ecological Modeling (Ft. Collins, Colo.), 1982.

- 3-134. McKinion, J. M., and D. N. Baker: Modeling, Experimentation, Verification, Validation: Closing the Feedback Loop. Trans. ASAE, paper number 79-4515, 1980, pp. 647-653.
- 3-135. Meyer, W. S., and J. T. Ritchie: Resistance to Water Flow in the Sorghum Plant. Plant Physiol., vol. 65, no. 1, 1980, pp. 33-39.
- 3-136. Meyer, W. S., and J. T. Ritchie: Water Status of Cotton as Related to Taproot Length. Agron. J., vol. 72, no. 4, 1980, pp. 577-580.
- 3-137. Moeschberger, M. D.: Model Testing and Evaluation. Dept. of Statistics, Univ. of Mo. (Columbia), 1980.
- 3-138. Morgan, J. A.: Interaction of Water Supply and N in Wheat. Plant Physiol. (in press).
- 3-139. Morgan, J. A.: Nitrogen Nutrition and Water Deficit Effects on Stomatal Response and Gas Exchange of Spring Wheat Leaves. Plant Physiol., vol. 72, 1983, p. 68.
- 3-140. Morgan, J. A., and R. H. Brown: Photosynthesis and Growth of Bermudagrass Swards, I. Carbon Dioxide Exchange Characteristics of Swards Mowed at Weekly and Monthly Intervals. Crop Sci., vol. 23, 1983, pp. 347-352.
- 3-141. Morgan, J. A., and R. H. Brown: Photosynthesis and Growth of Bermudagrass Swards, II. Characteristics of Growth As Determined by Harvest and Gas Exchange Techniques. Crop Sci., vol. 23, 1983, pp. 352-357.
- 3-142. Morgan, J. A., and W. O. Willis: Gas Exchange and Water Relations of "Olaf" Spring Wheat. Crop Sci., vol. 23, 1983, pp. 541-546.
- 3-143. Morgan, J. A., and W. O. Willis: Shading Effects on Photosynthate Distribution and Yield of "Vona" Winter Wheat. ASA Abs., vol. 96, 1983.
- 3-144. Morgan, J. A., D. N. Baker, W. Parton, C. V. Cole, W. O. Willis, D. Smika, A. Bauer, and A. L. Black: Simulation of Climatic and Management Effects on Wheat Production. Analysis of Ecological Systems: State-of-the-Art in Ecological Modeling (W. K. Lauenroth, C. V. Skogerboe, and M. Flug, eds.), Elsevier Pub. Co. (New York) 1983, pp. 517-524.
- 3-145. Motha, R. P.: Barley Models for North Dakota and Minnesota. NOAA (Columbia, Mo.), 1980.
- 3-146. Motha, R. P.: Crop Yield Model Review. NOAA (Columbia, Mo.), 1980.
- 3-147. Motha, R. P.: Soybean Models for Iowa, Illinois, and Indiana. NOAA (Columbia, Mo.), 1980.
- 3-148. Musick, J. T., and D. A. Dusek: Planting Data and Water Deficit Effects on Development and Yield of Irrigated Winter Wheat. Agron. J., vol. 72, 1980, pp. 45-52.
- 3-149. Padgett, M. M.: Technical and Economic Causes of U.S. Corn and Soybean Yield Changes. Sept. 1982.
- 3-150. Parsons, J. E., C. J. Phene, D. N. Baker, J. R. Lambert, and J. M. McKinion: Soil Water Stress and Photosynthesis in Cotton. Physiologia Plantarum, vol. 47, 1980, pp. 185-189.
- 3-151. Peterson, C. M., B. Klepper, R. W. Rickman: The Contributions of Seed Reserves and the First Three Leaves to Seedling Development of Winter Wheat. Agron. Abstr., 1982, p. 107.
- 3-152. Peterson, C. M., B. Klepper, and R. W. Rickman: Tiller Development at the Coleoptilar Node in Winter Wheat. Agron. Abs., 1981, p. 112.
- 3-153. Peterson, C. M., B. Klepper, and R. W. Rickman: Tiller Development at the Coleoptilar Node in Winter Wheat (*Triticum aestivum* L.). Agron. J., vol. 74, 1982, pp. 781-784.
- 3-154. Peterson, C. M., R. W. Rickman, and B. Klepper: The Influence of Light on Leaf and Tiller Development in Winter Wheat. Plant Physiol., vol. 65, 1980, p. 133.
- 3-155. Pikul, J. L., Jr.: Calculated and Field-Measured Soil Heat Flux: A Comparison Under Two Soil Water Regimes. M.S. Thesis, Ore. State Univ. (Corvallis), 1983.
- 3-156. Pikul, J. L., Jr.: Formation of Soil Frost as Influenced by Crop Residue Management. 1982 Research Report - Columbia Basin Agric. Res. Spec. Rep. 661. Oregon Agric. Exp. Sta. (Corvallis), 1982, pp. 31-36.
- 3-157. Pikul, J. L., Jr., and R. R. Allmaras: Calculated and Field-Measured Soil Heat Flux: A Comparison Under Two Soil-Water Regimes. Agron. Abs., 1982, p. 255.
- 3-158. Pikul, J. L., Jr., R. R. Allmaras, and C. R. Rohde: Water Movement Through Tillage Pans After 52 Years of Crop Residue Management. 1983 Research Report - Columbia Basin Agric. Res. Spec. Rep. 680, Oregon Agric. Exp. Sta. (Corvallis), 1983, pp. 8-13.
- 3-159. Pinter, P. J., Jr., R. D. Jackson, S. B. Idso, and R. J. Reginato: Multidate Spectral Reflectances as Predictors of Yield in Water Stressed Wheat and Barley. Int. J. Remote Sensing (in press).
- 3-160. Pun, E. P. C., and S. K. Katti: Evaluating Models by Sample Reuse Methods. Dec. 1981.
- 3-161. Ramig, R. E.: No-Till Annual Cropping. Proc. Pendleton-Walla Walla Fertilizer Dealer's Conference (Walla Walla, Wash.) Jan. 1983, pp. 1-11.
- 3-162. Ramig, R. E.: Should I Try No-Till? Oregon Wheat, vol. 33, no. 11, Nov. 1982, p. 20.
- 3-163. Ramig, R. E.: Yes, Recropping Is a Viable Option! Oregon Wheat, vol. 33, no. 7, July 1982, pp. 9-10.
- 3-164. Ramig, R. E., et al.: Reduced Tillage Systems and Water Conservation. 1982 Annual Rep. no. 8, STEEP (Richland, Wash.), Jan. 1983, pp. 145-146.
- 3-165. Ramig, R. E. and L. G. Ekin: No-Till Annual Cropping. 1983 Research Report - Columbia Basin Agric. Res. Spec. Rep. 680. Oregon Agric. Exp. Sta. (Corvallis), 1983, pp. 23-28.
- 3-166. Ramig, R. E., R. R. Allmaras, and R. I. Papendick: Water Conservation: Pacific Northwest. Dryland Agriculture, Amer. Soc. Agron. Monograph 23. (Madison, Wis.), 1983, pp. 105-124.
- 3-167. Rasmussen, Paul E.: Fertilizer Application for Cereal Grains Grown With Conservation Tillage. Oregon Wheat (OWGL, Pendleton), Sept. 1983.
- 3-168. Rasmussen, Paul E.: Winter Wheat Response to Nitrogen Fertilizer in No-Till Annual Cropping and Conventional Tillage Wheat-Fallow Rotation. 1983 Research Report - Columbia Basin Agric. Res. Spec. Rep. 680. Oregon Agric. Expt. Sta. (Corvallis), 1983, pp. 16-17.
- 3-169. Rasmussen, P. E., and C. R. Rohde: Long-Term Changes in Soil C, N, and pH Produced by $\text{NH}_4\text{-N}$ Fertilization. 1983 Annual Meeting, American Soc. Agron. (Madison, Wis.). Agron. Abstr., 1983, p. 178.
- 3-170. Rasmussen, P. E., R. E. Ramig, and D. E. Wilkins: Wheat and Barley Response in Conservation Tillage Systems. Proc. Thirty-Fourth Fertilizer Conf. of the Northwest (Portland, Ore.), July 1983, pp. 49-56.

- 3-171. Rasmussen, P. E., D. E. Wilkins, and R. W. Rickman: Effect of Starter Fertilizer Solutions on Wheat Emergence, Stand, and Fall Growth. 1980 Research Report - Columbia Basin Agric. Res. Spec. Rep. 571. Oregon Agric. Exp. Station (Corvallis), 1980, pp. 48-52.
- 3-172. Ratliff, L. F., J. T. Ritchie, and D. K. Cassel: A Survey of Field-Measured Limits of Soil Water Availability and Related Laboratory-Measured Properties. *Proc. Soil Sci. Soc. America*, vol. 47, 1983, pp. 770-775.
- 3-173. Richardson, A. J., D. E. Escobar, H. W. Gausman, and J. H. Everitt: 1980 Comparison of Landsat-2 and Field Spectrometer Reflectance Signatures of South Texas Rangeland Communities. Sixth Annual Symposium on Machine Processing of Remotely Sensed Data, Purdue Univ. (W. Lafayette, Ind.), June 2-6, 1980.
- 3-174. Rickman, R. W., and B. L. Klepper: Using Air Temperature to Anticipate Wheat Crop Development. 1983 Research Report - Columbia Basin Agric. Research Spec. Rep. 680. Oregon Agric. Exp. Sta. (Corvallis), 1983, pp. 28-36.
- 3-175. Rickman, R. W., and B. L. Klepper: Wet-Season Aeration Problems Beneath Surface Mulches in Dryland Wheat Production. *Agron. J.*, vol. 75, 1980, pp. 733-736.
- 3-176. Rickman, R. W., B. L. Klepper, and C. M. Peterson: Tiller Production by Stephens Wheat. 1980 Res. Report - Columbia Basin Agric. Res. Spec. Rep. 571. Oregon Agric. Exp. Station (Corvallis), 1980, pp. 78-82.
- 3-177. Rickman, R. W., B. L. Klepper, and C. M. Peterson: Time Distributions for Describing Appearance of Specific Culms of Wheat. *Agron. Abstr.*, 1981, p. 113.
- 3-178. Rickman, R. W., B. L. Klepper, and C. M. Peterson: Time Distributions for Describing Appearance of Specific Culms of Winter Wheat. *Agron. J.*, vol. 75, 1983, pp. 551-556.
- 3-179. Rickman, R. W., B. L. Klepper, and C. M. Peterson: 1982. Wheat Seedling Growth and Developmental Response to Incident Photosynthetically Active Radiation. *Agron. Abs.*, p. 108.
- 3-180. Righes, A. A.: Water Uptake and Root Distribution of Soybean, Grain Sorghum, and Corn. Ph. D. Dissertation, Iowa State Univ., 1980.
- 3-181. Ritchie, J. T.: Efficient Water Use in Crop Production: Discussion on the Generality of Relations Between Biomass Production and Evapotranspiration. Limitations to Efficient Water Use in Crop Production. ASA Special Publication, 1983, pp. 29-44.
- 3-182. Ritchie, J. T.: Plant Stress Research and Crop Production: The Challenge Ahead. (N. C. Turner and P. J. Kramer, eds.) *Adaptation of Plants to Water and High Temperature Stress*, John Wiley & Sons, Inc., 1980, pp. 21-29.
- 3-183. Samet, J. S., and T. R. Sinclair: Leaf Senescence and Absciscic Acid in Leaves of Field-Grown Soybeans. *Plant Physiol.*, vol. 66, 1980, pp. 1163-1168.
- 3-184. Sebaugh, J. L.: Evaluation of the CEAS Trend and Monthly Weather Data Models for Spring Wheat Yields in North Dakota and Minnesota. Dec. 1981.
- 3-185. Sebaugh, J. L.: Evaluation of the Feyerherm '81 Spring Wheat Models for Estimating Yields in North Dakota and Minnesota. June 1983.
- 3-186. Sebaugh, J. L.: Review of the Michaels Model for Predicting Corn Yields in Virginia. 1983.
- 3-187. Sebaugh, J. L. and J. T. Cotter: Comparison of the CEAS and Thompson-Type Models for Soybean Yields in Iowa, Illinois, and Indiana. June 1983.
- 3-188. Sinclair, T. R.: Leaf CER From Post-Flowering to Senescence of Field-Grown Soybean Cultivars. *Crop Sci.*, vol. 20, 1980, pp. 196-200.
- 3-189. Sinclair, T. R.: Plant Organ Chambers in Field Plant Physiology Research. *Hort. Sci.*, vol. 15, 1980, pp. 620-623.
- 3-190. Sinclair, T. R., and S. C. Spaeth: Physiological and Environmental Limits to Soybean Yields. *Proc. Symposium on Physiological Aspects of Soybean Yield, Carbon-Nitrogen Interaction in Crop Production* (Coop. Japan-USA Science Program). Hokkaido National Agric. Exp. Sta., Faculty of Agriculture, Hokkaido Univ. (Sapporo, Japan), Oct. 5, 1982, pp. 1-11.
- 3-191. Sinclair, T. R., D. G. Lugg, and S. C. Spaeth: Comparative Fixation and Utilization of Carbon and Nitrogen Among Soybean Genotypes. (R. J. Summerfield and A. H. Bunting, eds.) *Advances in Legume Science*, Roy. Botanic Gardens (Kew, England), 1980, pp. 313-322.
- 3-192. Smika, D. E., A. L. Black, D. N. Baker, W. O. Willis, and A. Bauer: WHEAT - A Model Simulating Growth and Yield in Wheat. Fortran Code. Paper no. 18229, 1980.
- 3-193. Snyder, J. R., M. D. Skold, and W. O. Willis: Economics of Snow Management for Agriculture in the Great Plains. *J. Soil and Water Conserv.*, vol. 35, 1980, pp. 21-24.
- 3-194. Stone, J. F., and W. O. Willis, eds. *Plant Production and Management Under Drought Conditions*. Elsevier Scientific Publishing Co., 1983.
- 3-195. Strand, B. W.: Spatial Scale of Crop-Yield Models. A Review of the Relationship Between Scale of Models and Accuracy. USDA, ESS, SRD. ESS Staff Rep. AGESS 810320, 1981.
- 3-196. Thompson, W. A., Jr.: On Model Testing and Evaluation. Dept. of Statistics, Univ. of Mo. (Columbia), 1980.
- 3-197. Tucker, C. J., J. H. Elgin, Jr., and J. E. McMurtrey III: Relationship of Crop Radiance to Alfalfa Agronomic Values. *Int. J. Remote Sensing*, vol. 1, no. 1, 1980, pp. 69-75.
- 3-198. Tucker, C. J., B. N. Holben, J. H. Elgin, Jr., and J. E. McMurtrey III: Relationship of Spectral Data to Grain Yield Variation. *Photogrammetric Eng. and Remote Sensing*, vol. 46, no. 5, 1980, pp. 657-666.
- 3-199. Tucker, C. J., B. N. Holben, J. H. Elgin, Jr., and J. E. McMurtrey III: Remote Sensing of Total Dry-Matter Accumulation in Winter Wheat. NASA Tech. Memo. 80631, 1980.
- 3-200. Upchurch, D. R., and J. T. Ritchie: Root Observations Using a Video Recording System in Mini-Rhizotrons. *Agron. J.*, vol. 75, 1983, pp. 1009-1015.
- 3-201. Upchurch, D. R., J. T. Ritchie, and M. A. Foale: Design of a Large Dual-Structure Rainout Shelter. *Agron. J.*, vol. 75, 1983, pp. 845-848.
- 3-202. Virji, H., and R. A. Bryson: Objective Aggregation of Meteorological Data for Use in Crop Yield Estimations, Final Report. NOAA Grant NA80AA-D-0054.
- 3-203. Wang, J. R., J. C. Shiue, and J. R. McMurtrey III: Microwave Remote Sensing of Soil Moisture Content Over Bare and Vegetated Fields. NASA Tech. Memo. 80669, 1980.

3-204. Wang, J. R., J. C. Shiue, and J. E. McMurtrey III: Microwave Remote Sensing of Soil Moisture Content Over Bare and Vegetated Fields. *Geophys. Res. Letters*, vol. 7, no. 10, 1980, pp. 801-804.

3-205. Whisler, F. D.: Sensitivity Tests of the Environmental Variables in RICEMOD. *IRRI Res. Paper Ser. 88*, 1983.

3-206. Whisler, F. D.: Sensitivity Tests of the Crop Variables in RICEMOD. *IRRI Res. Paper Ser. 89*, 1983.

3-207. Whisler, F. D.: Soil Data Preparation for Crop Growth Models. *Agron. Sci. Ser. no. 1*, 1982.

3-208. Whisler, F. D., J. R. Lambert, and J. A. Landivar: Predicting Tillage Effects on Cotton Growth and Yield. Predicting Tillage Effects on Soil Physical Properties and Processes. *American Soc. of Agron. (Madison, Wis.)* 1982, pp. 179-198.

3-209. Wiegand, C. L., and J. A. Cuellar: Direction of Grain Filling and Kernel Weight of Wheat as Affected by Temperature. *Crop Sci.*, vol. 21, 1981, pp. 95-101.

3-210. Wiegand, C. L., A. H. Gerbermann, and J. A. Cuellar: Development and Yield of Hard Red Winter Wheat Under Subtropical Conditions. *Agron. J.*, vol. 73, no. 1, 1981, pp. 29-38.

3-211. Willis, W. O.: Water Conservation: Introduction. *Dryland Agriculture* (H. E. Dregne and W. O. Willis, eds.) *American Soc. Agron. Monograph*, no. 23, 1983, pp. 21-24.

3-212. Willis, W. O., A. Bauer, and A. L. Black: Water Conservation: Northern Great Plains. *Dryland Agriculture. American Soc. Agron. Monograph*, no. 23, 1983, pp. 73-88.

3-213. Willis, W. O.: Water Conservation for Semiarid Rangelands. *Proc. Int. Atomic Energy Agency Advisory Group Meeting on Use of Nuclear Techniques in Improving Pasture Management* (cosponsored by ICARDA), Vienna, Austria (in press).

3-214. Willis, W. O.: Water and Soil Conservation Practices in the Northern Great Plains. *Proc. Alberta Soil Sci. Workshop* (Edmonton, Alberta), 1983, pp. 139-140.

3-215. Willis, W. O., M. D. Skold, and J. R. Snyder: Snow Management and Its Economic Potential in the Great Plains. *Proc. Nat. Conf. on Climate and Risk* (sponsored by MIT and NRC). (L. Pocinki, ed.), May 27-29, 1980, Arlington, Va. (in press).

3-216. Wilson, W. W., and J. L. Sebaugh: Established Criteria and Selected Methods for Evaluating Crop Yields Models in the AgRISTARS Program. 1981.

3-217. Wilson, W. W., T. Barnett, S. LeDuc, and F. Warren: Crop Yield Model Test and Evaluation Criteria. 1980.

3-218. Xekalaki, E., and S. K. Katti: Rating Models Based on Concordance with Observed Data. Aug. 1981.

3-219. Yule, D. F., and J. T. Ritchie: Soil Shrinkage Relationships of Texas Vertisols. I. Small Cores. *Soil Sci. Soc. America J.*, vol. 44, no. 6, 1980, pp. 1285-1291.

3-220. Yule, D. F., and J. T. Ritchie: Soil Shrinkage Relationships of Texas Vertisols. II. Large Cores. *Soil Sci. Soc. America J.*, vol. 44, no. 6, 1980, 1291-1295.

4. SR Requirements

4-01. Crop Calendar Preprocessor Requirements Document. SR-11-00201, NAS 9-14350, May 1981.

Task Descriptions

4-02. ERSYS-SPP Access Method Subsystem Design Specification. MU-11-00300, Sept. 1980. NTIS: 85N15493.

4-03. "As-Built" Design Specification for UNIV 4 VEC. SR-L1-00301, JSC-17389, LEMSCO-16676, May 1981. NTIS: 82N21637.

4-04. "As-Built" Design Specification for PARCLS. SR-L1-00302, JSC-17390, LEMSCO-16677, June 1981. NTIS: 82N21642.

4-05. "As-Built" Design Specification for the CLASFYT Program. SR-L1-00303, JSC-17370, LEMSCO-16648, May 1981. NTIS: 82N22539.

4-06. "As-Built" Design Specification for the CLASFYC Program. SR-L1-00304, JSC-17369, LEMSCO-16649, June 1981. NTIS: 82N21644.

4-07. "As-Built" Design Specification for PARHIS. SR-L1-00305, JSC-17371, LEMSCO-16650, Apr. 1981. NTIS: 82N21641.

4-08. "As-Built" Design Specification for Map (SGMAP) Program. SR-L1-00306, JSC-17037, LEMSCO-15937, Dec. 1980. NTIS: 82N21646.

4-09. "As-Built" Design Specification for MISMAP. SR-L1-00307, JSC-17231, LEMSCO-16300, June 1981. NTIS: 82N21643.

4-10. "As-Built" Design Specification for PARPLT. SR-L1-00308, JSC-17305, LEMSCO-16544, June 1981. NTIS: 82N22543.

4-11. Description of the Fortran Implementation of the Spring Grains Planting Date Distribution Model. SR-L1-00309, JSC-17414, LEMSCO-16854, Aug. 1981. NTIS: 82N23608.

4-12. "As-Built" Design Specification for GTPURE. SR-L2-00312, JSC-17810, LEMSCO-17606, Jan. 1982. NTIS: 82X74790.

4-13. ERSYS Registration Subsystem Detailed Design Specification. SR-I2-00313, NAS 9-14350, Sept. 1981. NTIS: 82X74792.

4-14. ERSYS User Interface Subsystem Design Specification. SR-I2-00314, JSC-16921, NAS 9-14350, Oct. 1981.

4-15. "As-Built" Design Specification for the Accuracy Assessment Software Package for the NAS-3000 Computer. SR-L3-00315, JSC-18605, LEMSCO-18920, Mar. 1983.

4-16. Multi-Channel Mars C/X-Band Scatterometer System, vol. 1: Design and Operation. SR-K3-00316, NCC 9-4, Apr. 1983.

4-17. Multi-Channel Mars C/X-Band Scatterometer System, vol. 2: System Specifications and Experimental Data. SR-K3-00317, NCC 9-4, Apr. 1983.

Reports

4-18. Experimental Design Considerations for Analyst and Segment Effects in Crop Proportion Estimates. SR-I9-00400, NAS 9-14350, Nov. 1979.

4-19. Crop Classification With Landsat Multispectral Scanner Data II. SR-I9-00401, NAS 9-14350, Nov. 1979.

4-20. Final Report: Development and Evaluation of Clustering Procedures. SR-T9-00402, NAS 9-14689, Nov. 1979. NTIS: 80N18526.

- 4-21. Informal Progress Review. SR-J9-00403, Nov. 30, 1980.
- 4-22. Final Report: Development of Landsat-Based Technology for Crop Inventories. SR-E9-00404, NAS 9-15476, Dec. 1979. NTIS: 80N18506.
- 4-23. Final Report: Development of Landsat-Based Technology for Crop Inventories: Appendices. SR-E9-00404, NAS 9-15476, Dec. 1979. NTIS: 80N18507.
- 4-24. Crop Yield Literature Review for AgRISTARS Crops: Corn, Soybeans, Wheat, Barley, Sorghum, Rice, Cotton, and Sunflowers. SR-L9-00405, JSC-16320, LEC-13791, Dec. 1979. NTIS: 80N23748.
- 4-25. Composition and Assembly of a Spectral Data Base for Corn and Soybean Multicrop Segments. SR-L0-00407, JSC-13773, LEMSCO-14250, June 1980. NTIS: 80N29824.
- 4-26. Quantitative Estimation of Plant Characteristics Using Spectral Measurement: A Survey of the Literature. SR-L0-00408, JSC-16298, LEMSCO-14077, Jan. 1980.
- 4-27. Crop Phenology Literature Review for Corn, Soybean, Wheat, Barley, Sorghum, Rice, Cotton, and Sunflower. SR-L9-00409, JSC-16088, LEC-13722, Nov. 1979. NTIS: 82N19610.
- 4-28. Final Report: Agricultural Scene Understanding and Supporting Field Research. SR-P9-00410, NAS 9-15466, vol. I, Nov. 1979. NTIS: 80N23740.
- 4-29. Final Report: Processing Techniques Development Part 1: Crop Inventory Techniques. SR-P9-00411, NAS 9-15466, Vol. II, Nov. 1979. NTIS: 80N23741.
- 4-30. Final Report: Processing Techniques Development Part 2: Data Preprocessing and Information Extraction Techniques. SR-P9-00412, NAS 9-15466, vol. III, Nov. 1979. NTIS: 80N23742.
- 4-31. Final Report: Computer Processing Support. SR-P9-00413, NAS 9-15466, vol. IV, Nov. 1979. NTIS: 80N23743.
- 4-32. Final Report: Annual Technical Summary. SR-P9-00414, NAS 9-15466, Nov. 1979. NTIS: 80N30823.
- 4-33. Variability of Crop Calendar Stage Dates. SR-L0-00416, JSC-16309, LEMSCO-14070, Jan. 1980. NTIS: 80N23706.
- 4-34. Composition and Assembly of a Spectral Data Base for Transition Year Spring Wheat Blind Sites, Volume I. SR-L0-00417, JSC-16273, LEMSCO-14069, Jan. 1980. NTIS: 80N23747.
- 4-35. Interpretation of Landsat Digital Data Using a Cubic Color Model Based on Relative Energies. SR-L0-00418, JSC-13776, LEMSCO-13499, Feb. 1980.
- 4-36. Utilization of Spectral-Spatial Information in the Classification of Imagery Data. SR-L0-00419, JSC-16335, LEMSCO-14310, June 1980.
- 4-37. January 1980 Supporting Research Task Manager's Report. SR-J0-00421, Jan. 31, 1980.
- 4-38. Label Identification From Statistical Tabulation (LIST) Temporal Extendability Study. SR-L0-00424, JSC-16334, LEMSCO-14278, Feb. 1980. NTIS: 80N26735.
- 4-39. A Labeling Technology for Landsat Imagery. SR-L0-00425, JSC-16341, LEMSCO-14357, May 1980. NTIS: 80N30861.
- 4-40. Final Report: Procedure M System Description Document. SR-I0-00426, NAS 9-14350, Oct. 1979.
- 4-41. Estimation of Probabilities of Label Imperfections and Correction of Mislabels. SR-L0-00427, JSC-16342, LEMSCO-14356, Mar. 1980. NTIS: 80N30856.
- 4-42. Label Identification From Statistical Tabulation (LIST) Application of RIDIT Analysis. SR-L0-00430, JSC-16345, LEMSCO-14390, Mar. 1980. NTIS: 80N27764.
- 4-43. Physiocochemical, Site, and Bidirectional Reflectance Factor Characteristics of Uniformly Moist Soils. SR-P0-00431, NAS 9-15466, Feb. 1980. NTIS: 80N26721.
- 4-44. Final Report: Development of AI Procedures for Dealing With the Effects of Episodal Events on Crop Temporal-Spectral Response and Development of AI Guidelines for Corn & Soybean Labeling. SR-B9-00434, NAS 9-14565, Nov. 1979.
- 4-45. Semi-Annual Project Management Report. SR-J0-00435, JSC-16349, Mar. 1980.
- 4-46. AgRISTARS Cropping Practices and Crop Characteristics Based on 1979 ESCS Observations. SR-J0-00438, JSC-16353, Apr. 1980. NTIS: 80N30860.
- 4-47. Some Approaches to Optimal Cluster Labeling of Aerospace Imagery. SR-L0-00440, JSC-16355, LEMSCO-14597, Mar. 1980. NTIS: 80N29820.
- 4-48. An Exploratory Study to Develop a Cluster-Based Area Estimation Procedure. SR-L0-00442, JSC-16358, LEMSCO-14670, May 1980. NTIS: 80N30863.
- 4-49. Contextual Classification of Multispectral Image Data. SR-P0-00443, NAS 9-15466, Jan. 1980. NTIS: 80N26716.
- 4-50. Context Distribution Estimation for Contextual Classification of Multispectral Image Data. SR-P0-00444, NAS 9-14566, Apr. 1980. NTIS: 80N26723.
- 4-51. Spatial-Spectral Procedure Development: The Purity Experiment. SR-I0-00445, NAS 9-14350, Apr. 1980.
- 4-52. Crop Calendars for the U.S., U.S.S.R, and Canada in Support of the Early Warning Project. SR-L0-00450, JSC-16359, LEMSCO-14673, July 1980.
- 4-53. Purity Data Report. SR-I0-00452, NAS 9-14350, Apr. 14, 1980.
- 4-54. Evaluation of Bayesian Sequential Proportion Estimation Using Analyst Labels. SR-L0-00453, JSC-16361, LEMSCO-14355, May 1981. NTIS: 80N30871.
- 4-55. Pixel Labeling by Supervised Probabilistic Relaxation. SR-P0-00454, NAS 9-15466, Feb. 1980. NTIS: 80N29814.
- 4-56. On the Accuracy of Pixel Relaxation Labeling. SR-P0-00455, NAS 9-15466, Mar. 1980.
- 4-57. Evaluating the Use of Analyst Labels in Maximum Likelihood Cluster Proportion Estimation. SR-L0-00456, JSC-16538, LEMSCO-14672, Apr. 1980. NTIS: 80N30870.
- 4-58. Interpolation of Daily and Monthly Precipitation and Temperature Using the Wagner Variational Analysis Technique. SR-J0-00457, JSC-16504, Mar. 1980.
- 4-59. Effects of Management Practices on Reflectance of Spring Wheat Canopies. SR-P0-00458, NAS 9-15466, May 1980.
- 4-60. An Algorithm for Estimating Crop Calendar Shifts of Spring Small Grains Using Landsat Spectral Data. SR-E0-00459, NAS 9-15476, June 1980.
- 4-61. Sampling of Rectangular Regions. SR-L0-00460, JSC-16362, LEMSCO-14806, June 1980. NTIS: 80N29819.

- 4-62. Multispectral Data Analysis Based on Ground Truth Crop Classes. SR-I0-00461, NAS 9-14350, June 1980.
- 4-63. Proportion Estimation Using Prior Cluster Purities. SR-L0-00465, JSC-16754, LEMSCO-15163, July 1980.
- 4-64. Minimum Variance Geographic Sampling. SR-L0-00467, JSC-16370, LEMSCO-15179, July 1980.
- 4-65. A Multispectral Data Simulation Technique. SR-P0-00469, NAS 9-15466, July 1980. NTIS: 80N33830.
- 4-66. Canadian Crop Calendars in Support of the Early Warning Project. SR-L0-00475, JSC-16376, LEMSCO-14676, Aug. 1980.
- 4-67. Preliminary Evaluation of the Environmental Research Institute of Michigan Crop Calendar Shift Algorithm for Estimation of Spring Wheat Development Stage. SR-L0-00476, JSC-16377, LEMSCO-15115, Sept. 1980.
- 4-68. The Numerical Trails of HISSE. SR-H0-00477, NAS 9-14689, Aug. 1980.
- 4-69. The Multicategory Case of the Sequential Bayesian Pixel Selection and Estimation Procedure. SR-L0-00478, JSC-16378, LEMSCO-14807, Nov. 1980. NTIS: 81N29498.
- 4-70. A Semi-Automatic Technique for Multitemporal Classification of a Given Crop. SR-J0-00481, JSC-16381, July 1979.
- 4-71. Taxonomic Classification of World Soil Map Units Occurring in Selected Brazilian States With Representative U.S. Soil Series and Numerical Rating of Physical and Chemical Soil Properties Significant to Crop Production. SR-U0-00482, JSC-16383, Sept. 1980.
- 4-72. Probabilistic Cluster Labeling of Imagery Data. SR-L0-00483, JSC-16384, LEMSCO-15358, Sept. 1980. NTIS: 82N22590.
- 4-73. Normal Crop Calendars, Volume I: Assembly and Application of Historical Crop Data to a Standard Product. SR-L0-00484, JSC-16813, LEMSCO-15033, Aug. 1980.
- 4-74. Normal Crop Calendars, Volume II: The Spring Wheat States of Minnesota, Montana, North Dakota, and South Dakota. SR-L0-00485, JSC-16814, LEMSCO-15034, Aug. 1980.
- 4-75. Badhwar, G. D., and K. E. Henderson: Development Stage Estimation of Corn From Spectral Data - An Initial Model. SR-J0-00488, JSC-16816, Aug. 1980. (Submitted to Agron. J.).
- 4-76. Illustration of Year-to-Year Variation in Wheat Spectral Profile Crop Growth Curves. SR-J0-00489, JSC-16817, Aug. 1980.
- 4-77. Contextual Classification of Multispectral Imagery Data Approximate Algorithm. SR-P0-00491, NAS 9-15466, Aug. 1980.
- 4-78. On the Existence, Uniqueness, and Asymptotic Normality of a Consistent Solution of the Likelihood Equations for Nonidentically Distributed Observations-Applications to Missing Data Problems. SR-H0-00492, NAS 9-14689, Sept. 1980.
- 4-79. An Assessment of Landsat Data Acquisition History by Identification and Area Estimation of Corn and Soybeans. SR-P0-00494, NAS 9-15466, June 1980.
- 4-80. Taxonomic Classification of World Map Units in Crop Producing Areas of Argentina and Brazil With Representative U.S. Soil Series and Major Land Resource Areas in Which They Occur. SR-U0-00497, JSC-16824, Oct. 1980. NTIS: 82N19633.
- 4-81. Spectral Reflectance of Soils: A Literature Review. SR-J0-00498, JSC-16825, Aug. 1980.
- 4-82. Classification of Wheat: Badhwar Profile Similarity Technique. SR-L0-00499, JSC-16826, LEMSCO-15305, Oct. 1980. NTIS: 81N31598.
- 4-83. A Semi-Automatic Technique for Multitemporal Classification of a Given Crop of a Landsat Scene. SR-J0-04001, JSC-16829, Oct. 1980.
- 4-84. Preliminary Evaluation of Spectral, Normal, and Meteorological Crop Stage Estimation Approaches. SR-L0-04002, JSC-16830, LEMSCO-14640, Oct. 1980. NTIS: 82N19634.
- 4-85. Maximum Likelihood Estimation for Mixture Models. SR-J0-04007, JSC-16832, LEMSCO-14880, Oct. 1980. NTIS: 81N33564.
- 4-86. Semi-Annual Project Management Report Program Review Presentation to Level, Interagency Coordination Committee. SR-J0-04011, JSC-16836, Nov. 1980.
- 4-87. Analysis of U.S. Spring Wheat and Spring Barley Periodic Ground Truth. SR-L0-04012, JSC-16837, LEMSCO-15698, Jan. 1981. NTIS: 81N32576.
- 4-88. Investigation of Boundary Pixel Handling Procedures. SR-L0-04013, JSC-16838, LEMSCO-15679, Dec. 1980.
- 4-89. Bias Modeling Experiment. SR-I0-04015, NAS 9-14350, Nov. 1980.
- 4-90. Quasi-Field Purity Experiment. SR-I0-04017, NAS 9-14350, Oct. 1980.
- 4-91. U.S.S.R. Crop Calendars in Support of the Early Warning Project. SR-L0-04019, JSC-16844, LEMSCO-14675, Dec. 1980.
- 4-92. Final Report: Field Research on the Spectral Properties of Crop and Soil. SR-P0-04022, NAS 9-15466, Nov. 1980. NTIS: 81N26527.
- 4-93. Final Report: Research in the Application of Spectral Data to Crop Identification and Assessment. SR-P0-04023, NAS 9-15466, Nov. 1980. NTIS: 81N26528.
- 4-94. Final Report: Data Processing Research and Techniques Development. SR-P0-04024, NAS 9-15466, Nov. 1980.
- 4-95. Final Report: Computer Processing Support. SR-P0-04025, NAS 9-15466, Nov. 1980.
- 4-96. Spatial/Color Sequence Proportion Estimation Techniques. SR-L0-04028, JSC-16848, LEMSCO-15641, Dec. 1980.
- 4-97. A Comparative Study of the Thematic Mapper and Landsat Spectral Bands From Field Measurement Data. SR-J0-04029, JSC-16849, Mar. 1981. NTIS: 81N33549.
- 4-98. Maximum Likelihood Clustering With Dependent Feature Trees. SR-L1-04031, JSC-16853, LEMSCO-15683, Jan. 1981. NTIS: 81N29502.
- 4-99. Spring Small Grains Planting Date Distribution Model. SR-L1-04032, JSC-16858, LEMSCO-16018, Mar. 1981. NTIS: 82N23581.

- 4-100. Assembly Language Coding for CLASSY. SR-X1-04033, NAS 9-15981, Jan. 1981.
- 4-101. Weighted Ratio Estimation of Large Area Crop Production. SR-J1-04036, JSC-16861, Feb. 1981. NTIS: 81N33567.
- 4-102. Possible Modification of the HISSE Model for Pure Landsat Agricultural. SR-H1-04037, NAS 9-14689, Feb. 1981.
- 4-103. Soybean Canopy Reflectance as Influenced by Cultural Practices. SR-P1-04038, NAS 9-15466, Mar. 1981. NTIS: 82N21647.
- 4-104. Canopy Reflectance as influenced by Solar Illumination Angle. SR-P1-04039, NAS 9-15466, Mar. 1981. NTIS: 82N23610.
- 4-105. Maximum Likelihood Labeling. SR-X1-04041, NAS 9-15981, Feb. 1981. NTIS: 81N33563.
- 4-106. Crop Classification Using Airborne Radar and Landsat Data. SR-K1-04043, NAS 9-15421, Feb. 1981.
- 4-107. Effects of Nitrogen Nutrition on the Growth, Yield and Reflectance Characteristics of Corn Canopy. SR-P1-04044, NAS 9-15466, May 1981. NTIS: 82N20591.
- 4-108. Classification of Corn: Badhwar Profile Similarity Technique. SR-L1-04045, JSC-17113, LEMSCO-16035, Aug. 1981. NTIS: 82N21676.
- 4-109. Improved Version of the Split Routine for CLASSY. SR-X1-04046, NAS 9-15981, Mar. 1981. NTIS: 81N31600.
- 4-110. New Output Improvements for CLASSY. SR-X1-04053, NAS 9-15981, Mar. 1981. NTIS: 81N29503.
- 4-111. A Temporal/Spectral Analysis of Small Grain Crops and Confusion Crops. SR-L1-04054, JSC-17128, LEMSCO-15676, Mar. 1981. NTIS: 81N28498.
- 4-112. Interim Catalog, Ground Data Summary Data Acquisition Year 1979. MU-L1-04055, JSC-17119, LEMSCO-16207, Feb. 1981. NTIS: 82N19608.
- 4-113. Interim Catalog, Ground Data Summary Data Acquisition Year 1978. MU-L1-04056, JSC-17120, LEMSCO-16325, Mar. 1981. NTIS: 81N33546.
- 4-114. A Crop Moisture Stress Index for Large Areas and Its Application in the Prediction of Spring Wheat Phenology. SR-L1-04064, JSC-17121, LEMSCO-16216, Mar. 1981. NTIS: 81N33573.
- 4-115. Development and Evaluation of an Automatic Labeling Technique for Spring Small Grains. SR-E1-04065, NAS 9-15476, Aug. 1981. NTIS: 82N15480.
- 4-116. Estimation of Proportions in Mixed Pixels Through Their Region Characterization. SR-L1-04067, JSC-17124, LEMSCO-16021, Mar. 1981.
- 4-117. An Analysis of Haze Effect on Landsat Multispectral Scanner Data. SR-L1-04071, JSC-17127, LEMSCO-15971, Mar. 1981. NTIS: 81N29497.
- 4-118. Design and Evaluation of a Pick-Up Truck Mounted Boom for Evaluation of a Multiband Radiometer System. SR-P1-04079, NAS 9-15466, Apr. 1981.
- 4-119. Performance Comparison for Barnes Model 12-1000, EXOTECH Model 100, and Ideas, Inc., Biometer Mark II. SR-P1-04090, NAS 9-15466, Apr. 1981.
- 4-120. Recommended Data Sets, Corn Segments and Spring Wheat Segments, for Use in Program Development. SR-L1-04094, JSC-17137, LEMSCO-15708, Apr. 1981.
- 4-121. Six-Channel Thematic Mapper Simulation. SR-L1-04098, JSC-17139, LEMSCO-16342, May 1981.
- 4-122. Preliminary Catalog: Ground Data Summary Data Acquisition for 1980. MU-L1-04100, JSC-17365, LEMSCO-16644, May 1981.
- 4-123. Development of Advanced Acreage Estimation Method. SR-T1-04112, NAS 9-14689, Dec. 1980. NTIS: 81N29495.
- 4-124. U.S. Crop Calendar in Support of the Early Warning Project. SR-L1-04122, JSC-17402, LEMSCO-14674, July 1981. NTIS: 82N21682.
- 4-125. Interim Catalog, Ground Data Summary Data Acquisition Year 1977. MU-L1-04123, JSC-17403, LEMSCO-16938, July 1981. NTIS: 82X74788.
- 4-126. On the Accuracy of Pixel Relaxation Labeling. SR-P1-04125, NAS 9-15466, July 1981.
- 4-127. Documentation of Computer Procedures for Labeling Spring Grains and Discriminating Between Spring Wheat and Barley Using Landsat Data. SR-E1-04131, NAS 9-15476, Aug. 1981. NTIS: 82N16448.
- 4-128. Empirically Determined Calibration Differences Between MDP-LIVES and LACIE Processed Data. SR-J1-04133, JSC-17412, June 1981.
- 4-129. Notes for Brazil Sampling Frame Evaluation Trip. SR-E1-04138, NAS 9-15476, Aug. 1981. NTIS: 82N19635. NTIS: 82N19635.
- 4-130. Linear Polarization of Light by Two Wheat Canopies Measured at Many View Angles. SR-P1-04139, NAS 9-15466, Sept. 1981. NTIS: 82N23602.
- 4-131. Diurnal Changes in Reflectance Factor Due to Sun-Row Direction Interactions. SR-P1-04140, NAS 9-15466, Sept. 1981. NTIS: 82N23566.
- 4-132. Application of Computer Axial Tomography to Measuring Crop Canopy Geometry. SR-P1-04141, NAS 9-15466, June 1981. NTIS: 82N23600.
- 4-133. Incorporating Spatial Concept into Statistical Classification of Multidimensional Image Data. SR-P1-04148, NAS 9-15466, Aug. 1981. NTIS: 82N22856.
- 4-134. Evaluation of Trends in Wheat Yield Models. SR-J1-04157, JSC-17428, Dec. 1982.
- 4-135. Evaluation of Several Schemes for Classification of Remotely Sensed Data. SR-P1-04158, NAS 9-15466, 1979.
- 4-136. Regression Model Estimation of Early Season Crop Proportions: North Dakota, Some Preliminary Results. SR-L1-04158, JSC-17429, LEMSCO-17156, Jan. 1982. NTIS: 82N24552.
- 4-137. A Method for Classifying Multispectral Remote Sensing Data Using Context. SR-P1-04159, NAS 9-15466, 1979.
- 4-138. Sampling for Area Estimation: A Comparison of Full-Frame Sampling With the Sample Segment Approach. SR-P1-04160, NAS 9-14970, 1979.
- 4-139. Analysis of Scanner Data for Crop Inventories - Period Covered November 15, 1979 - February 15, 1980. MU-E1-04161, NAS 9-15476, May 1980.
- 4-140. Analysis of Scanner Data for Crop Inventories - Period Covered February 16, 1980 - May 15, 1980. MU-E1-04162, NAS 9-15476, May 1980.
- 4-141. Analytical Design of Multispectral Sensors. SR-P1-04163, NAS 9-15466, Apr. 1980.

- 4-142. Overcoming Accuracy Deterioration in Pixel Relaxation Labeling. SR-P1-04164, NAS 9-15466, Dec. 1980.
- 4-143. Evaluation of Several Schemes for Classification of Remotely Sensed Data. SR-P1-04165, NAS 9-15466, Dec. 1980.
- 4-144. Contextual Classification of Multispectral Remote Sensing Data Using a Multiprocessor System. SR-P1-04166, NAS 9-15466, Apr. 1980.
- 4-145. Parallel Processing Implementations of a Contextual Classifier for Multispectral Remote Sensing Data. SR-P1-04167, NAS 9-15466, June 1980.
- 4-146. The Development of a Spectral-Spatial Classifier for Earth Observations Data. SR-P1-04168, NAS 9-15466, Aug. 1979.
- 4-147. A Parametric Model for Multispectral Scanners. SR-P1-04169, NAS 9-15466, Apr. 1980.
- 4-148. A Model of Plant Canopy Polarization Response. SR-P1-04170, NAS 9-15466, June 1980.
- 4-149. 1981 Argentina Ground Data Collection. SR-E1-04174, NAS 9-15476, Oct. 1981. NTIS: 82N21658.
- 4-150. Spectral Agronomic Relationships of Corn, Soybean, and Wheat Canopies. SR-P1-04187, NAS 9-15466, Oct. 1981. NTIS: 82N21670.
- 4-151. Ground Truth Crop Proportion Summary for U.S. Segment, 1976-1979. SR-E1-04189, NAS 9-15476, Oct. 1981. NTIS: 82N25595.
- 4-152. Variability of Reflectance Measurement With Sensor Altitude in Canopy Type. SR-P1-04191, NAS 9-15466, Nov. 1981. NTIS: 82N21672.
- 4-153. Multistage Classification of Multispectral Earth Observational Data: The Design Approach. SR-P1-04194, NAS 9-15466, Dec. 1981.
- 4-154. Semi-Annual Project Management Report - Program Review Presentation to Level I Interagency Coordination Committee. SR-J1-04195, JSC-17792, Nov. 1981. NTIS: 82N23592.
- 4-155. Spectral Properties of Agricultural Crop and Soils Measured from Space, Aerial, Field, and Laboratory Sensors. SR-P1-04200, NAS 9-15466, Nov. 1981. NTIS: 82N22623.
- 4-156. A Multiband Radiometer and Data Acquisition System for Remote Sensing Field Research. SR-P1-04201, NAS 9-15466, Nov. 1981. NTIS: 82N21669.
- 4-157. Simulated Response of a Multispectral Scanner Over Wheat as a Function of Wavelength and View/Illumination Direction. SR-P1-04202, NAS 9-15466, Nov. 1981. NTIS: 82N21671.
- 4-158. The Extension of a Uniform Canopy Reflectance Model to Include Row Effect. SR-E1-04265, NAS 9-15476, Dec. 1981. NTIS: 82N24537.
- 4-159. The Akaike Information Criterion and Its Application to Mixture Proportion Estimation. SR-T1-04207, NAS 9-14689, Sept. 1981.
- 4-160. Mars X-Band Scatterometer. SR-K1-04213, NAS 9-15421, Nov. 1981. NTIS: 82N24557.
- 4-161. Coherent Optical Determination of the Leaf Angle Distribution of Corn. SR-K1-04214, NAS 9-15421. NTIS: 82N24560.
- 4-162. Crop Classification Using Multidate/Multifrequency Radar Data. SR-K2-04220, NAS 9-15421, Dec. 1981. NTIS: 82N24559.
- 4-163. Agronomic Characterization of the Argentina Indicator Region. SR-E2-04222, NAS 9-14565, Jan. 1982. NTIS: 82N24561.
- 4-164. Cultural and Environmental Effects on the Spectral Development Patterns of Corn and Soybeans - Field Data Analysis. SR-E2-04224, NAS 9-15476, Jan. 1982. NTIS: 82N24536.
- 4-165. Within-Field Variability of Plant and Soil Parameters. SR-K2-04227, NAS 9-15421, Dec. 1981. NTIS: 82N24562.
- 4-166. Spectral Estimates of Solar Radiation Intercepted by Corn Canopy. SR-P2-04236, NAS 9-15466, Mar. 1982. NTIS: 82N26742.
- 4-167. Algorithms for Scene Modeling. SR-X2-04260, NAS 9-16446, Mar. 1981.
- 4-168. Final Report: Remote Sensing of Agricultural Crops and Soils. SR-P2-04266, NAS 9-15466, May 1982.
- 4-169. Semi-Annual Program Review Presentation to Level I, Interagency Coordination Committee. SR-J2-04271, JSC-17831, Apr. 20, 1982.
- 4-170. LARSPEC Spectroradiometer - Multiband Radiometer Data Formats. SR-P2-04277, NAS 9-16528, and NAS 9-15466, May 1982.
- 4-171. Soybean Canopy Reflectance as a Function of View in Illumination Geometry. SR-P2-04278, NAS 9-15466, Apr. 1982. NTIS: A82-27645.
- 4-172. Key Issues in the Analysis of Remote Sensing Data. SR-P2-04292, NAS 9-15466, June 1981.
- 4-173. Monitoring Global Vegetation. LARS Seventh Int. Symposium (W. Lafayette, Ind.), SR-J2-04300, JSC-18242, June 1981.
- 4-174. Characteristic Variations in Reflectance of Surface Soils. SR-P2-04301, NAS 9-15466, May 1982.
- 4-175. A Three-Part Geometric Model to Predict the Radar Backscatter From Wheat, Corn, and Sorghum. SR-K2-04313, Apr. 1982.
- 4-176. Final Report: Development of Advanced Acreage Estimation Methods. SR-T2-04317, NAS 9-14689, June 1982.
- 4-177. Performance Evaluation and Calibration of Modular Multiband Radiometer for Remote Sensing and Field Research. SR-P2-04318, NAS 9-15466, June 1982.
- 4-178. Extension of Laboratory Measured Soil Spectra to Field Conditions. SR-P2-04326, NAS 9-15466, June 1982.
- 4-179. Data Documentation for the 1981 Summer Vegetation Experiment. SR-K2-04336, NAS 9-15421, May 1982.
- 4-180. Development of Thematic Mapper Vegetative Indices for Assessing Biomass in Corn, Soybeans, and Wheat. SR-J2-04337, JSC-18264, Aug. 1982.
- 4-181. Leaf Area Estimates from Spectral Measurements Over Various Planting Date of Wheat. SR-M2-04341, NAS 9-16457, Sept. 1982.
- 4-182. Intercepted Photosynthetically Active Radiation in Wheat NAS Canopies Estimated by Spectral Reflectance. SR-M2-04342, NAS 9-16457, Sept. 1982.
- 4-183. Program to Compute the Positions of the Aircraft and of the Aircraft Sensor Footprints. SR-J2-04360, JSC-18574, Sept. 1982.
- 4-184. Spatial and Spectral Simulation of Landsat Images of Agricultural Areas. SR-E1-04206, NAS 9-15476, Mar. 1982.

4-185. Linear Discriminate Analysis With Misallocation in Training Samples. SR-L3-04388, JSC-18590, LEMSCO-19020, Dec. 1982.

4-186. On the Error in Crop Acreage Estimation Using Satellite (Landsat) Data. SR-L3-04389, JSC-18591, LEMSCO-19021, Jan. 1983.

4-187. Composition and Assembly of a Spectral and Agronomic Data Base for 1980 Spring Small Grain Segments. SR-L3-04392, JSC-18593, LEMSCO-19023, Jan. 1983.

4-188. Analysis of Seasonal Multispectral Reflectances of Small Grain. SR-M3-04401, NAS 9-16457, Mar. 1983.

4-189. Final Report: Establishment of a Center of Excellence for Applied Mathematical and Statistical Research. SR-63-04408, NAS 9-16438, Jan. 1983.

4-190. Proportion Estimation and Mixtures of Asymmetric Distribution. SR-63-04409, NAS 9-16438, May 1983.

4-191. Seasonal In Situ Spectral Reflectance Measurements of Small Grain in South Dakota. SR-03-04411, NAS 9-16457, Apr. 1983.

4-192. Radar Remote Sensing for Crop Classification and Canopy Condition Assessment: Ground Data Documentation. SR-K3-04424, NCC 9-4, Apr. 1983.

4-193. Argentina Spectral-Agronomic Multitemporal Data Set. SR-L3-04426, JSC-18884, LEMSCO-19539, June 1983.

4-194. Minimum Distance Estimation of Mixture Models Parameters - Asymptotic Results and Simulation Comparisons With Maximum Likelihood. SR-63-04427, NAS 9-16438, June 1983.

4-195. Separability of Agricultural Crops With Airborne Scatterometry. SR-L3-04428, JSC-18885, LEMSCO-19422, June 1983.

4-196. Data Management Procedures for Tiepoint Registration, Pre- and Post-Processing, and "ICD116." SR-L3-04430, JSC-18886, LEMSCO-19428, June 1983.

4-197. Light Interception and Leaf Area Index Estimated From Spectral Reflectance in Wheat. SR-M3-04431, NAS 9-16457, July 1983.

4-198. Relating the Radar Backscattering Coefficient to Leaf Area Index. SR-K3-04432, NAS 9-15421, Apr. 1983.

4-199. Minimum Hellinger Distance Estimation of Mixture Model Parameters. SR-63-04433, NAS 9-16438, July 1983.

4-200. Canopy Reflectance as Influenced by Leaf Angle. SR-T3-04434, NAS 9-16674, July 1983.

4-201. Update and Review of Accuracy Assessment Techniques for Remotely Sensed Data. SR-T3-04435, NAG 5-31, Jan. 1983.

4-202. A Simulation Study of Scene Confusion Factors in Sensing Soil Moisture From Orbital Radar. SR-K3-04438, Aug. 1983.

4-203. Final Report: Center of Excellence for Applied Mathematical and Statistical Research in Support of Development of Multicrop Production Monitoring Capability. SR-63-04444, NAS 9-16438, Aug. 1983.

Minutes

4-204. Minutes of the Semi-Annual Formal Project Manager's Review. SR-J0-00503, JSC-16839, Oct. 7, 1980.

Plans

4-205. Supporting Research Project Implementation Plan. SR-J9-C0602, JSC-16340, Dec. 1979.

4-206. Supporting Research Project Implementation Plan. SR-J0-C0615, JSC-16834, Oct. 1980.

4-207. Supporting Research Project Implementation Plan (FY82 and FY83). SR-J1-00636, JSC-17417, Apr. 1982.

4-208. Argentina Ground Data Collection Plan for 1981-1982 Crop Year. SR-E1-00644, NAS 9-15476, NAS 9-14565, Nov. 1981. NTIS: 82X74798.

4-209. Supporting Research Project Research Plan Document. SR-J2-00652, JSC-18247, June 1982.

4-210. Supporting Research Project Implementation Plan for Fiscal Year 1983. SR-J2-C0653, JSC-18266, Sept. 1983.

Procedures

4-211. As-Built Documentation of Programs to Implement the Robertson and Doraiswamy/Thompson Models. SR-L1-00717, JSC-17400, LEMSCO-16376, June 1981. NTIS: 82N21638.

4-212. User Guide to Spring Small Grain Planting Date Distribution Model. SR-L1-00720, JSC-17410, LEMSCO-16669, Aug. 1981.

4-213. Semi-Automated Procedure for Producing High-Purity Labels for Corn and Soybean Crops. SR-L1-00726, JSC-17786, LEMSCO-17105, Nov. 1981.

4-214. User's Guide for the Profile Parameter Classification System. SR-L1-00727, JSC-17655, LEMSCO-17272, Aug. 1981. NTIS: 82X74789.

4-215. Development of a Corn and Soybean Labeling Procedure for Use With Profile Parameter Classification. SR-L2-00750, JSC-18257, LEMSCO-17765, June 1982.

4-216. Accuracy Assessment User's Guide for NAS-3000. SR-L2-00757, JSC-18586, LEMSCO-18927, Dec. 1982.

4-217. User Guide for the Extraction of Landsat Spectral and Agronomic Data. SR-L3-00761, JSC-18598, LEMSCO-19253, Jan. 1983.

Unnumbered Documents

4-218. Amis, M. L., R. K. Lenington, M. V. Martin, W. C. McGuire, and S. S. Shen: Evaluation of Large Area Crop Estimation Techniques. Fifteenth Int. Symposium on Remote Sensing of the Environment (Ann Arbor, Michigan), vol. 2, May 11-15, 1981.

4-219. Badhwar, G. D., J. G. Carnes, and W. Austin: Use of Landsat-Derived Temporal Profiles for Corn-Soybean Feature Extraction and Classification. Remote Sensing of Environment, vol. 12, Mar. 1982, pp. 57-79.

4-220. Cicone, R., E. Crest, R. Kauth, P. Lambeck, N. Malila; and W. Richardson: Development of Procedure M for Multicrop Inventory, With Tests of a Spring Wheat Configuration. Environmental Research Inst. of Mich., NASA CR ERIM 132400-16-F, Mar. 1979.

4-221. Crist, E., and W. Malila: A Technique for Automatic Labeling of Landsat Agricultural Scene Elements by Analysis of Temporal-Spectral Patterns. Fifteenth Int. Symposium on Remote Sensing of the Environment, May 1981.

- 4-222. Crist, E. P., and W. A. Malila: Temporal-Spectral Analysis Technique for Vegetation Applications of Landsat. Fourteenth Int. Symposium on Remote Sensing of the Environment (San Jose, Costa Rica), Apr. 1980.
 - 4-223. Doraiswamy, P., and D. Thompson. Nov.-Dec. 1980, An Agromet Crop Phenology Model for Spring Wheat. American Society of Agronomy, Crop Sci. Soc. of America, Soil Sci. Soc. of America, Nov.-Dec. 1980.
 - 4-224. Feiveson, A.: Aids for the Identification of Statistical Concepts. The Joint Statistical Meeting of the American Stat. Assoc. and Biometric Soc. (Houston, Tex.), Aug. 1980.
 - 4-225. Hay, C. M., L. H. Beck, and E. J. Sheffner: Remote Sensing of Arid and Semi-Arid Lands. Int. Symposium on Remote Sensing of the Environment, (Cairo, Egypt), Jan. 1982.
 - 4-226. Holmes, Q. A., and R. Horvath: Procedure M: An Advanced Procedure for Stratified Area Estimation Using Landsat. Fourteenth Int. Symposium on Remote Sensing of the Environment (San Jose, Costa Rica), Apr. 1980.
 - 4-227. Kauth, R. J., and G. S. Thomas: System for Analysis of Landsat Agricultural Data. Environmental Res. Inst. of Michigan, NASA CR ERIM 109600.
 - 4-228. Kauth, R. J., R. C. Cicone, and W. A. Malila: Procedure M: A Framework for Stratified Area Estimation. Sixth Annual Symposium on Machine Processing of Remotely Sensed Data, Purdue Univ. (W. Lafayette, Ind.), June 2-6, 1980.
 - 4-229. Kauth, R. J., W. A. Malila, R. Horvath, and R. C. Cicone: Design Consideration for Resource Inventory Systems. Fourteenth Int. Symposium on Remote Sensing of the Environment (San Jose, Costa Rica), Apr. 1980.
 - 4-230. Lenington, R. K., and M. E. Rassbach: CLASSY-An Adaptive Maximum Likelihood Clustering Algorithm. Proc. Technical Sessions, The LACIE Symposium, Vol. II, July 1979, pp. 671-691. (See ref. 1 for availability.)
 - 4-231. Malila, W. A., P. F. Lambeck, and E. P. Crist: Landsat Features for Agricultural Applications. Fourteenth Int. Symposium on Remote Sensing of the Environment (San Jose, Costa Rica), Apr. 1980.
 - 4-232. Pitts, D., and G. Badhwar: Field Size, Length, and Width Distributions Based on LACIE Ground Truth Data. Remote Sensing of Environment, 1980, pp. 201-213.
 - 4-233. Richards, J. A., D. A. Landgrebe, and P. H. Swain: Pixel Labeling by Supervised Probabilistic Relaxation. IEEE Trans. Pattern Analysis and Machine Intelligence, vol. Pami-3, no. 2, Mar. 1981.
 - 4-234. Seminar by Bob Sielken at Mathematics Dept. of Univ. of S. Dak., Spring 1980. Reports 18, 19, and 20.
 - 4-235. Thompson, D., and O. Wehmanen: Using Landsat Digital Data to Detect Moisture Stress in Corn-Soybean Growing Regions. Photogrammetric Eng. and Remote Sensing, vol. 46, no. 8, Aug. 1980, pp. 1087-1093.
5. SM Instructions
 - 5-01. Yield Model Development/Soil Moisture Interface Control Document. MU-J0-00100, JSC-16841, Nov. 1980. NTIS: 82N19629.
 - 5-02. Soil Moisture/Early Warning and Crop Condition Assessment Interface Control Document. MU-J0-00101, JSC-16842, Nov. 1980. NTIS: 82N19628.
 - 5-03. Neutron-Meter Calibration for the 1978 Colby Soil Moisture Experiment. SM-L0-00415, JSC-13775, LEMSCO-14082, Feb. 1980.
 - 5-04. Evaluation of Gravimetric Ground Truth Soil Moisture Data Collected for the Agricultural Soil Moisture Experiment 1978 Colby, Kansas, Aircraft Mission. SM-L0-00441, JSC-16357, LEMSCO-14600, Oct. 1980. NTIS: 81N29494.
 - 5-05. Kanemasu, E. T., A. Feyerherm, J. Hanks, M. Keener, D. Lawlor, P. Rasmussen, H. Reetz, K. Saxton, and C. Wiegand: Use of Soil Moisture Information in Crop Yield Models. SM-M0-00462, NAS Tech. Memo. 9-14899, Evapotranspiration Lab., Kansas State Univ. (Manhattan), June 1980.
 - 5-06. Agricultural Soil Moisture Experiment, Colby, Kansas, 1978: Measured and Predicted Hydrologic Properties of the Soil. SM-L0-00463, JSC-16366, LEMSCO-14307, Oct. 1980. NTIS: 82N19632.
 - 5-07. A Parametric Study of Tillage Effects on Radar Backscatter. SM-J0-00470, JSC-16372, July 1980.
 - 5-08. Wang, J., J. Shive, E. T. Engman, J. McMurtrey, G. P. Lawless, T. J. Schmugge, T. J. Jackson, W. Gould, J. Fuchs, C. Calhoon, T. Carriahan, E. Hirschmann, and W. Glazar: Remote Measurements of Soil Moisture by Microwave Radiometers at BARC Test Site. SM-G0-00471, Aug. 1980.
 - 5-09. Comparison of the Characteristics of Soil Water Profile Models. SM-L0-00490, JSC-16818, LEMSCO-15330, Jan. 1981.
 - 5-10. Joint Microwave and Infrared Studies for Soil Moisture Determination. SM-Y0-00495, NAS 7-100, Sept. 1980.
 - 5-11. Armand, N. A., F. A. Mkrtchyan, and A. M. Shutko: Computer Realization of Algorithms for Charting the Moisture Content of Soil by UHF Radiometric Data. SM-G2-00800, GSFC, Dec. 1982.
 - 5-12. Comparison of Ground and Airborne Remote Sensing Radar Measurements. SM-K0-04004, NAG 5-30, Oct. 1980.
 - 5-13. Aircraft Radar Response to Soil Moisture. SM-K0-04005, NAG 5-30, Oct. 1980.
 - 5-14. 1978 Agriculture Soil Moisture (ASME) Data Documentation. SM-K0-04006, NAG 5-30, Oct. 1980.
 - 5-15. Data Documentation for the Bare Soil Experiment at the University of Arkansas. SM-A0-04008, NAS 9-14251, Jan. 1980.
 - 5-16. Soil Moisture Project Evaluation Workshop. SM-R0-04016, Nov. 1980.
 - 5-17. Calculations of the Spectral Nature of the Microwave Emissions From Soil. SM-G0-04018, NASA Tech. Memo. 82002, Nov. 1980. NTIS: 81N24495.
 - 5-18. Descriptive and Sensitivity Analyses of WATBAL1: A Dynamic Soil Water Model. SM-L0-04021, JSC-16846, LEMSCO-15672, Mar. 1981. NTIS: 81N29507.
 - 5-19. Final Report: Agriculture Soil Moisture Experiment. SM-K1-04035, NAS 9-14052, Jan. 1981.
 - 5-20. Agricultural Soil Moisture Experiment: Evaluation of 1978 Colby Data Collected for Comparative Testing of Soil Moisture Models. SM-L1-04047, JSC-17115, LEMSCO-15324, May 1981.

- 5-21. Ulaby, F. T., F. Kouyate, A. K. Fung, and A. J. Sieber: A Backscattering Model for a Randomly Perturbed Periodic Surface. SM-K1-04048, RSL TR 460-4, NAG 5-30, Univ. of Kans., Apr. 1981. *Also*, IEEE Int. Geoscience and Remote Sensing Symposium, IGARSS-81, (Washington, D.C.), June 8-10, 1981, cat. no. 81-CH1656-8, vol. 2, pp.1280-1293. *Also*, IEEE Trans. Geoscience and Remote Sensing, vol. GE-20, no. 4, Oct. 1982, pp. 518-528.
- 5-22. An Approximate Model for Backscattering and Emission for Land and Sea. SM-K1-04049, NAG 5-30, Mar. 1981.
- 5-23. A Parameterization of Effective Soil Temperature for Microwave Emission. SM-G1-04050, NASA Tech. Memo. 82100, Mar. 1981. NTIS: 81N24494.
- 5-24. Airborne Microwave Remote Sensing of Soil Moisture. SM-T1-04057, NAG 5-31, Mar. 1981.
- 5-25. Application of Strong Fluctuation Random Medium Theory to Scattering of Electromagnetic Waves from a Half Space of Dielectric Mixture. SM-T1-04058, NAG 5-31, Mar. 1981.
- 5-26. Field Calibration of the Dual-Tube Gamma Soil Moisture Gauge. SM-T1-04060, NAG 5-31, Mar. 1981.
- 5-27. Spatial Variability of Hydraulic Properties of Soil as Described by Scaling and Its Relation to Remotely Sensed Soil Parameters. SM-T1-04063, NAG 5-31, Mar. 1981.
- 5-28. Survey of Applications of Passive Microwave Remote Sensing for Soil Moisture in the U.S.S.R. SM-R1-04084, May 1981.
- 5-29. A Computer Program for the Simulation of Heat and Moisture Flow in Soils. SM-G1-04086, Apr. 1981.
- 5-30. Ground Registration of Data From an Airborne Scatterometer. SM-L1-04091, JSC-17296, LEMSCO-16340, June 1981. NTIS: 82N21636.
- 5-31. Wang, J. R., J. E. McMurtrey III, E. T. Engman, T. J. Jackson, T. J. Schmugge, W. I. Gould, W. S. Glazar, and J. E. Fuchs: Radiometric Measurements Over Bare and Vegetated Fields at 1.4 GHz and 5 GHz Frequencies. SM-G1-04113, NASA Tech. Memo. 82151, GSFC, June 1981, NTIS: N822587. *Also*, Remote Sensing of Environment, vol. 12, 1982, pp. 295-311.
- 5-32. Ground Registration of Data From an Airborne Multifrequency Microwave Radiometer (MFM-R). SM-L1-04118, JSC-17152, LEMSCO-16800, Oct. 1981. NTIS: 82N22593.
- 5-33. The Effect of Soil Water Upon Soil Albedo. SM-T1-04128, NAG 5-31, June 1981.
- 5-34. Owe, M., E. B. Jones, and T. J. Schmugge: Soil Moisture Variation Patterns Observed in Hand County, South Dakota. SM-G1-04129, TM-82171, GSFC, Aug. 1981. NTIS: N8224535. *Also*, Water Resources Bull., vol. 18, no. 6, Dec. 1982, pp. 949-954.
- 5-35. Prisms Workshop Meeting Report - Vol. I, SM-G1-04135, Aug. 1981.
- 5-36. Prisms Workshop Meeting Report - Vol. II, Technical Presentations. SM-G1-04136, Aug. 1981.
- 5-37. Ground Truth Report: 1980 Texas A&M University Soil Moisture Experiment. SM-T1-04152, NAG 5-31, Sept. 1981.
- 5-38. A Model for Microwave Emission From Vegetation Covered Fields. SM-G1-04173, Oct. 1981.
- 5-39. Wang, J. R., T. J. Schmugge, J. E. McMurtrey III, W. I. Gould, W. S. Glazar, and J. E. Fuchs: A Multifrequency Radiometric Measurement of Soil Moisture Content Over Bare and Vegetated Fields. SM-G1-04178, NASA Tech. Memo. 83842, Oct. 1981. NTIS: 82N23611.
- 5-40. Ulaby, F. T., M. Razani, and M. C. Dobson: Effects of Vegetation Cover on the Microwave Radiometric Sensitivity to Soil Moisture. SM-K1-04179, RSL TR 460-6, NAG 5-30, Univ. of Kans., Mar. 1982. *Also*, IEEE Trans. Geoscience and Remote Sensing, vol. GE-21, no. 1, Jan. 1983, pp. 51-61.
- 5-41. Microwave Emission From a Periodic Soil Surface. SM-K1-04180, NAG 5-30, Nov. 1981.
- 5-42. A Model for the Radar Backscattering Coefficient of Bare Soil. SM-K1-04182, NAG 5-30, Jan. 1982.
- 5-43. Annual Report: Accomplishment of NASA Johnson Space Center Portion of the Soil Moisture Project in Fiscal Year 1981. SM-L1-04209, JSC-17798, LEMSCO-17305, Jan. 1982.
- 5-44. Ulaby, F. T., A. Aslam, and M. C. Dobson: Effects of Vegetation Cover on the Radar Sensitivity to Soil Moisture. SM-K1-04210, RSL TR 460-10, NAG 5-30, Univ. of Kans., Dec. 1981. *Also*, IEEE Trans. Geoscience and Remote Sensing, vol. GE-20, no. 4, Oct. 1982, pp. 476-481.
- 5-45. A Multifrequency Measurement of Thermal Microwave Emission From Soil: The Effect of Soil Texture and Surface Roughness. SM-G1-04218, Dec. 1981.
- 5-46. Camillo, P. J., and T. J. Schmugge: Estimation of Soil Moisture Storage in the Root Zone From Surface Measurements: SM-G2-04221, NASA Tech. Memo. 83885, GSFC, Jan. 1982. *Also*, Soil Sci. vol. 135, no. 4, Apr. 1983, pp. 245-264.
- 5-47. Fortran Implementation of Friedman's Test for Several Related Samples. SM-L2-04234, JSC-17816, LEMSCO-17502, Feb. 1982.
- 5-48. Active Reflector for Radar Calibration. SM-K2-04240, NAG 5-30, Feb. 1982.
- 5-49. A Comparison of Soil Moisture Characteristics Predicted by the Arya-Paris Model with Laboratory-Measured Data. SM-L2-04247, JSC-17820, LEMSCO-17187, Mar. 1982.
- 5-50. Ulaby, F. T., C. T. Allen, and A. K. Fung: Method for Retrieving the True Backscattering Coefficient From Measurements With a Real Antenna. SM-K2-04268, NAG 5-30, Univ. of Kans., Apr. 1982. *Also*, IEEE Int. Geoscience and Remote Sensing Symposium, IGARSS-82 (Munich, Germany), June 1-4, 1982, cat. no. 82-CH14723-5. *Also*, IEEE Trans. Geoscience and Remote Sensing, vol. GE-21, no. 3, July 1983, pp. 308-313.
- 5-51. The Effects of Vegetation Cover on the Radar and Radiometric Sensitivity to Soil Moisture. SM-K2-04269, NAG 5-30, Apr. 1982.
- 5-52. Semi-Annual Program Review Presentation to Level I, Interagency Coordination Committee. SM-U2-04274, JSC-18226, Apr. 10, 1982.
- 5-53. Computer Simulation of a Space SAR Using a Range-Sequential Processor for Soil Moisture Mapping. SM-K2-04284, NAS 9-16419, Apr. 1982.

- 5-54. Wang, J. R.: Passive Microwave Sensing of Soil Moisture Content: The Effects of Soil Bulk Density and Surface Roughness. SM-G2-04285, NASA Tech. Memo. 83937, GSFC, May 1982. *Also*, Remote Sensing of Environment, vol. 13, 1983, pp. 329-344.
- 5-55. Incoherent Scattering of Microwave From Rough Soil Surfaces. SM-G2-04291, May 1982.
- 5-56. Radar Cross Section Measurements Using a Radiometer Receiver. SM-K2-04299, NAG 5-30, May 1982.
- 5-57. Aircraft Active Microwave Measurements for Estimating Soil Moisture. SM-R2-04308, June 1980.
- 5-58. Aircraft Remote Sensing of Soil Moisture and Hydrologic Parameters, Taylor Creek, Florida, and Little River, Georgia, 1979 Data. SM-R2-04309, Sept. 1981.
- 5-59. Hawley, M., R. H. McCuen, and T. J. Jackson: Volume-Accuracy Relationship in Soil Moisture Sampling. SM-R2-04314, USDA-ARS, Mar. 1982. *Also*, J. Irrigation and Drainage Division, ASCE, vol. 108, no. 1R1, 1982, pp. 1-11.
- 5-60. Wang, J., P. O'Neill, E. Engman, J. McMurtrey III, R. Lawless, T. Schmugge, T. Jackson, W. Gould, J. Fuchs, and W. Glazar: Remote Measurement of Soil Moisture by Microwave Radiometers at BARC Test Site II. SM-G2-04315, NASA Tech. Memo. 83954, June 1982.
- 5-61. Measurement of Soil Moisture Using Remote Sensing Multisensor Radiation Techniques. SM-A2-04322, NAS 9-14251, May 1982.
- 5-62. Application of Numerical Integration of Laplace Transform In Estimating Thermal Diffusivity Near the Soil Surface: Uniform Initial Condition. SM-M2-04330, NAS 9-16457, July 1982.
- 5-63. Jackson, T. J.: Survey of Applications of Passive Microwave Remote Sensing for Soil Moisture in the U.S.S.R. USDA-ARS, SM-R2-04331, May 1982. *Also*, EOS, Trans. American Geophysical Union, vol. 63, no. 19, 1982, pp. 497-498.
- 5-64. Radar Backscatter Measurements of Periodic Soil Surfaces: Data Documentation. SM-K2-04339, NAG 5-30, Aug. 1982.
- 5-65. Aircraft Remote Sensing of Soil Moisture and Hydrologic Parameters, Chickasha, Oklahoma, 1980 Data Report. SM-R2-04352, July 1982.
- 5-66. Assessment of Radar Resolution Requirements for Soil Moisture Estimation from Simulated Satellite Imagery. SM-K2-04356, NAS 9-16419, Aug. 1982.
- 5-67. Investigation of Remote Sensing Techniques of Measuring Soil Moisture. SM-T2-04363, NAG 5-31, Jan. 1981.
- 5-68. Eom, H. J., and A. K. Fung: Backscattering Coefficient of a Perturbed Sinusoidal Surface. SM-K2-04371, RSL TR 460-13, NAG 5-30, Univ. of Kans., Sept. 1982.
- 5-69. Mo, T., T. J. Schmugge, and T. J. Jackson: Calculations of Radar Backscattering Coefficient of Vegetation-Covered Soils. SM-G3-04400, TM-85006, NAS 5-24350, GSFC, Mar. 1983. *Also*, Remote Sensing of Environment (to be published).
- 5-70. Method of Measuring Soil Moisture - A Bibliography. SM-R3-04403, Apr. 1983.
- 5-71. Dobson, M. C., P. Kouyate, and F. T. Ulaby: A Reexamination of Soil Textural Effects on Microwave Emission and Backscattering. SM-K3-04422, RSL TR 460-17, NAG 5-30, Univ. of Kan., May 1983.
- 5-72. Brunfeldt, D. R., and F. T. Ulaby: Measured Microwave Emission and Scatter in Vegetation Canopies. SM-K3-04423, RSL TR 460-18, NAG 5-30, Univ. of Kan., May 1983.
- 5-73. Newton, R. W., and M. R. Smith: Prediction of Root Zone Soil Moisture With a Water Balance Microwave Emission Model. SM-T3-04425, RSC TR 136, Tex. A&M Univ., May 1983.
- 5-74. Choe, Y., and L. Tsang: A Mathematical Characterization of Vegetation Effect on Microwave Remote Sensing From the Earth: SM-T3-04436, RSC TR 139 Tex. A&M Univ., Aug. 1983.
- 5-75. Tsang, L., and R. W. Newton: Microwave Emissions From Soils With Rough Interfaces. SM-T3-04445, RSC TR 107, Tex. A&M Univ., Nov. 1980. *Also*, J. of Geophysical Res., vol. 87, 1982, pp. 275-281.
- 5-76. Newton, R. W., B. V. Clark, and J. F. Paris: Microwave Systems Approach to Measuring Root Soil Moisture. SM-T3-04447, RSC TR 138, Tex. A&M Univ., June 1983.
- Plans
- 5-77. Experiment Plan: Row and Roughness Effects on Dependence of Active Microwave Measurements of Soil Moisture. SM-J0-00613, JSC-16822, LEMSCO-15181, Oct. 1980. NTIS: 81N33575.
- 5-78. Soil Moisture Implementation Plan. SM-J1-C0620, JSC-17108, 1981.
- 5-79. Soil Moisture Implementation Plan. SM-J1-C0627, JSC-17150, 1980.
- 5-80. Plan for Analysis of the Colby Agricultural Soil Moisture Experiment (ASME) Remote Sensing Data or Near-Surface Soil Moisture Prediction. SM-L1-00647, JSC-17796, LEMSCO-17289, Nov. 1981.
- 5-81. Soil Moisture Project Implementation Plan for Fiscal Years 1982 and 1983. SM-U1-00650, JSC-17802, Nov. 1981.
- 5-82. Soil Moisture Project Implementation Plan for Fiscal Year 1983. SM-U2-C0658, JSC-18570, Sept. 1983.
- Technical Translations
- 5-83. Determination of Changes in the Hydrolic and Thermal Profits of Soil by Simulation and Remote Sensing. SM-J1-00800, JSC-16857, Feb. 1981.
- Presentations
- 5-84. Engman, E. T.: Agricultural Needs Related to Satellite Hydrology. Fifth Annual Pecora Memorial Symposium (Sioux Falls, S. Dak.), June 10, 1979.
- Unnumbered Documents
- 5-85. Bouma, J., R. E. Paetzold, and R. B. Grossman: Application of Hydraulic Conductivity Measurements in Soil Moisture Survey. Soil Survey Investigations Rep., USDA-SCS (in press).

- 5-86. Bouma, J., R. F. Paetzold, and R. B. Grossman: Measuring Hydraulic Conductivity for Use in Soil Survey. Soil Survey Investigations Rep. no. 38, USDA-SCS, 1982, p. 14.
- 5-87. Choudhury, B. J.: A Parameterized Model for Global Insolation Under Partially Cloudy Skies. TM-82135, GSFC, May 1982. *ALeo*, Solar Energy, vol. 29, no. 6, 1982, pp. 479-486.
- 5-88. Choudhury, B. J., T. J. Schmugge, and T. Mo: Parameterization of Effective Soil Temperature for Microwave Emission. Publication in JGR, June 1980.
- 5-89. Engman, E. T.: Remote Sensing Input and Feedback for Hydrologic Forecasting and Simulation Models. Proc. Sixteenth Int. Symposium on Remote Sensing of the Environment, 1983, pp. 195-204.
- 5-90. Engman, E. T., T. J. Jackson, and T. J. Schmugge: Implications of Complete Watershed Soil Moisture Measurements to Hydrologic Modeling. Int. Geoscience and Remote Sensing Symposium (San Francisco) 1983, vol. 1.
- 5-91. Jackson, T. J.: Profile Soil Moisture From Surface Measurements. J. Irrigation and Drainage Division, ASCE, vol. 106, no. IR2, 1980, pp. 81-92.
- 5-92. Jackson, T. J., and P. O'Neill: Aircraft Scatterometer Observations of Soil Moisture on Rangeland Watersheds. Proc. American Soc. of Photogrammetry (Washington, D.C.), 1983.
- 5-93. Jackson, T. J., A. Chang, and T. J. Schmugge: Active Microwave Measurements for Estimating Soil Moisture in Oklahoma. Proc. Fall Technical Meeting of the ASP, 1980. Presented at Fall Technical Meeting of the ASP (Niagara Falls, N.Y.), Oct. 1980.
- 5-94. Jackson, T. J., A. Chang, and T. J. Schmugge: Aircraft Active Microwave Measurements for Estimating Soil Moisture. Photogrammetric Eng. and Remote Sensing, 1980 (accepted for publication).
- 5-95. Jackson, T. J., T. J. Schmugge, and P. O'Neill: Passive Microwave Remote Sensing of Soil Moisture from an Aircraft Platform. Remote Sensing of Environment, vol. 14, 1983.
- 5-96. Jackson, T. J., T. J. Schmugge, and P. O'Neill: Remote Sensing of Soil Moisture From an Aircraft Platform. Proc. Int. Symposium on Remote Sensing and Data Transmission (Hamburg, FRG), 1983.
- 5-97. Jackson, T. J., T. J. Schmugge, and J. R. Wang: Passive Microwave Sensing of Soil Moisture Under Vegetation Canopies. Water Resources Res., vol. 18, no. 4, 1982, pp. 1137-1142.
- 5-98. Jackson, T. J., T. J. Schmugge, A. D. Nicks, G. A. Coleman, E. T. Engman, and J. R. Wang: Analysis of Microwave Remote Sensing of Soil Moisture for Hydrologic Simulation. Int. Symposium on Recent Developments for Hydrological Forecasting (Oxford, England), Apr. 1980.
- 5-99. Jackson, T. J., T. J. Schmugge, G. A. Coleman, C. R. Richardson, A. Chang, J. Wang, and E. T. Engman: Aircraft Remote Sensing of Soil Moisture and Hydrologic Parameters, Chickasha, OK and Riesel, TX. 1978 Data Report ARR-NE-8, USDA SEA-AR (Beltsville, Md.), 1980.
- 5-100. Kondrat'yev, K. Y., and Y. V. Kurilova: Hydrological Cycles Studies by Aerospace Methods. CP-G2-00800, GSFC, Oct. 1982.
- 5-101. Matzkanin, G. A., and R. F. Paetzold: Measuring Soil Water Content Using Pulsed Nuclear Magnetic Resonance. Paper no. 82-2619, presented at ASAE Winter Meeting (Chicago, Ill.), Dec. 14-17, 1982.
- 5-102. Matzkanin, G. A., W. L. Rollwitz, J. D. King, and R. F. Paetzold: Principles of Nuclear Magnetic Resonance for Agricultural Operations. Presented at Nat. Conf. on Agric. Electronics Applications, ASAE (Chicago, Ill.), Dec. 11-13, 1983.
- 5-103. McKim, H. L., T. J. Schmugge, and T. J. Jackson: Survey of Methods for Soil Moisture Determination. Fourteenth Int. Symposium on Remote Sensing of the Environment (San Jose, Costa Rica), Apr. 1980.
- 5-104. Mo, T., and T. J. Schmugge: Effects of Uncertainties in Soil Moisture and Surface Roughness of the Microwave Emission From Soils. GSFC/CSC. *ALeo*, IEEE Trans. Geoscience and Remote Sensing, Oct. 1983.
- 5-105. Mo, T., and T. J. Schmugge: Monte Carlo Simulation of the Effect of Soil Moisture Variation on the Microwave Emission From Soils. NAS 5-24350, Task 250, 1983 GSFC/CSC. *ALeo*, IEEE Trans. Geoscience and Remote Sensing, vol. GE-21, no. 4, Oct. 1983, pp. 473-479.
- 5-106. Mo, T., B. J. Choudhury, T. J. Schmugge, J. R. Wang, and T. J. Jackson: A Model for Microwave Emission from Vegetation Covered Fields. J. of Geophysical Res., vol. 87, no. C13, Dec. 20, 1982, pp. 11,229-11,237.
- 5-107. Njoku, E. G., and P. E. O'Neill: Multifrequency Microwave Radiometer Measurements of Soil Moisture. NAS 7-100, JPL/GSFC. IEEE Trans. Geoscience and Remote Sensing, Oct. 1982, vol. GE-20, no. 4, pp. 468-475.
- 5-108. O'Neill, P., T. Jackson, B. Blanchard, et al.: The Effects of Vegetation and Soil Hydraulic Properties on Passive Microwave Sensing of Soil Moisture: Data Report for the 1982 Field Experiments, NASA Tech. Memo. 85106, 1983.
- 5-109. Paetzold, R. F., and T. J. Gish: Influence of Sensor and Soil Variables on NMR Measurement of Soil Water. Presented at ASA/SSSA annual meeting (Washington, D.C.), Aug. 14-19, 1983.
- 5-110. Paetzold, R. F., G. A. Matzkanin, and A. De Los Santos: Continuous Surface Soil Water Content Measurement Using Pulsed NMR. Paper no. 82-2618, presented at ASAE winter meeting (Chicago, Ill.), Dec. 14-17, 1982.
- 5-111. Paetzold, R. F., G. A. Matzkanin, and A. De Los Santos: Surface Soil Water Content Measurement Using Pulsed Nuclear Magnetic Resonance Techniques. Presented at ASA/SSSA annual meeting (Anaheim, Calif.), Nov. 28-Dec. 3, 1982.
- 5-112. Powell, R. L., C. Onasch, and R. M. Ragan: Near Surface Regional Ground Water Systems Modeling and Potential Applications for Remote Sensing. CP-G2-04361, NAG 5-9 Univ. of Md., Oct. 1982.
- 5-113. Price, J. C.: The Contribution of the Heat Capacity Mapping Mission to the Interpretation of Thermal Infrared Data. Proc. Symposium on Techniques for Extraction of Information From Remotely Sensed Images (Rochester, N.Y.), 1983 (to be published).
- 5-114. Price, J. C.: Estimating Surface Temperatures From Satellite Thermal Infrared Data - A Simple Formulation for the Atmospheric Effect. Remote Sensing of Environment, vol. 13, 1983, pp. 353-361.
- 5-115. Price, J. C.: Interpretation of Thermal Infrared Data to Augment Spectral Signatures. Int. Colloq. on Spectral Signatures of Objects in Remote Sensing (Bordeaux, France), 1983.

5-116. Price, J. C.: The Potential of Remotely Sensed Thermal Infrared Data to Infer Surface Soil Moisture and Evaporation. *Water Resources Res.* vol. 16, no. 6, 1980, pp. 787-795.

5-117. Price, J. C.: A Preliminary Comparison of the Information Content of Data From the Landsat 4 Thematic Mapper and Multispectral Scanner. *Proc. of the Landsat-4 Scientific Characterization Early Results Symposium*, Goddard Space Flight Center (Greenbelt, Md.), 1983 (to be published).

5-118. Price, J. C.: Satellite Estimation of Regional Scale Surface Moisture Characteristics. Meeting of American Geophysical Union (San Francisco, Calif.), Dec. 11, 1980.

5-119. Rango, A.: Hydrological Research in the AgRISTARS Program. Hydrological Applications of Remote Sensing and Remote Data Transmission. *Proc. of the Hamburg Symposium*, Aug. 1983, IAHS-AISH Publication, Int. Association of Hydrological Sciences (Hamburg, FRG), 1984.

5-120. Schmutge, T. J., T. J. Jackson, and H. L. McKim: Methods for Soil Moisture Determination. *Water Resources Res.*, vol. 16, no. 5, 1980, pp. 961-979.

5-121. Wang, J., and B. J. Choudhury: Remote Sensing of Soil Moisture Content Over Bare Fields at 1.4 GHz Frequency. *JGR*, June 20, 1981.

5-122. Wang, J., and T. Schmutge: An Empirical Model for the Complex Dielectric Permittivity of Soils as a Function of Water Content. *IEEE Trans. Geoscience and Remote Sensing*, vol. GE-18, no. 4, Oct. 1980.

5-123. Wang, J., R. Newton, and J. Rouse, Jr.: Passive Microwave Remote Sensing of Soil Moisture: The Effect of Tilled Row Structure. *IEEE Trans. Geoscience and Remote Sensing*, vol. GE-18, no. 4, Oct. 1980.

5-124. Wang, J. R., P. E. O'Neill, T. J. Jackson, and E. T. Engman: Multifrequency Measurements of the Effects of Soil Moisture, Soil Texture and Surface Roughness. *IEEE Trans. Geoscience and Remote Sensing*, vol. GE-21, no. 1, 1983, pp. 44-51.

5-125. Watts, F. C., H. F. Huckle, and R. F. Paetzold: Field Versus Laboratory Determined Hydraulic Conductivities of Some Slowly Permeable Horizons. *USDA-SCS. Soil Sci. Soc. of America J.*, vol. 46, 1982.

6. DC/LC

Reports

6-01. Evaluation of Large Area Crop Estimation Techniques Using Landsat and Ground-Derived Data. DC-L1-04051, JSC-17116, LEMSCO-15763, Mar. 1981.

6-02. Graham, M. H., and R. Luebke: An Evaluation of MSS P-Format Data Registration. DC-Y1-04069, NSTL/ERL-197, Apr. 1981.

6-03. Stoner, E. R., G. A. May, and M. T. Kalcic: Evaluation of Multiband, Multitemporal and Transformed Landsat MSS Data for Land Cover Area Estimation. DC-Y1-04089, NSTL/ERL-196, Apr. 1981.

6-04. An Analysis of Landsat MSS Scene-to-Scene Registration Accuracy. DC-Y1-04156, Dec. 1981. NTIS: 82N24563.

6-05. An Algorithm for Automating the Registration of USDA Segment Ground Data to Landsat MSS Data. DC-Y1-04211, Dec. 1981. NTIS: 82N24564.

6-06. Thematic Mapper Simulator Data Collected Over Eastern North Dakota. DC-Y1-04232, Apr. 1982.

6-07. Evaluation of Small Area Crop Estimation Techniques Using Landsat and Ground-Derived Data. DC-L2-04264, JSC-17829, LEMSCO-17597, Apr. 1982.

6-08. Semi-Annual Program Review Presentation to Level 1, Interagency Coordination Committee. DC-J2-04273, JSC-18223, Apr. 20, 1982.

6-09. Automated Segment Matching Algorithm Theory, Test and Evaluation. DC-Y2-04325, June 1982.

6-10. SCS Urban Curve Numbers from a Landsat Data Base. DC-R2-04353, Oct. 1981.

6-11. Analysis of Data Acquired by Synthetic Aperture Radar and Landsat Multispectral Scanner Over Kershaw County, South Carolina, During the Summer Season. DC-Y3-04374, NSTL/ERL-213, Mar. 1983.

6-12. Analysis of Data Acquired by Synthetic Aperture Radar Over Dade County, Florida, and Acadia Parish, Louisiana. DC-Y2-04396, NSTL/ERL-218, Dec. 1983.

6-13. Land Cover Change Monitoring Within the East-Central Louisiana Study Site - A Case for Large-Area Surveys With Landsat Multispectral Scanner Data. DC-Y3-04418, NSTL/ERL-221, June 1983.

6-14. Stratification of Sampled Land Cover by Soils for Landsat-Based Area Estimation and Mapping. DC-Y3-04439, NSTL/ERL-224, Sept. 1983.

6-15. A Correlation Analysis of Percent Canopy Closure vs. TMS Spectral Response for Selected Forest Sites in the San Juan National Forest, Colorado. DC-Y3-04440, NSTL/ERL-212, Nov. 1983.

6-16. Classification and Area Estimation of Land Covers in Kansas Using Ground-Gathered and Landsat Digital Data. DC-Y3-04441, NSTL/ERL-225, Dec. 1983.

Plans

6-17. Domestic Crops and Land Cover Implementation Plan. DC-J1-C0619, JSC-17109, 1981.

6-18. Domestic Crops and Land Cover Implementation Plan. DC-J1-C0626, JSC-17149, 1980.

6-19. Domestic Crops and Land Cover Project Implementation Plan for Fiscal Years 1982 and 1983. DC-U1-C0648, JSC-17799, Nov. 1981.

6-20. Domestic Crops and Land Cover Project Implementation Plan for Fiscal Year 1983. DC-U2-C0660, JSC-18585, Nov. 1983.

Unnumbered Documents

6-21. Allen, R.: USDA Registration and Rectification Requirements. NASA Workshop on Registration and Rectification, Nov. 17, 1981.

6-22. Colwell, R. N., R. W. Thomas, L. H. Beck, C. E. Brown, S. L. Wall: California Landsat-Aided Crop Estimation. Annual Report, 1 Jan. 1982 - 15 Jan. 1983, Space Sciences Laboratory, Univ. of Calif. (Berkeley), 1983.

6-23. Cook, P.: Landsat Registration Methodology Used by U.S. Department of Agriculture's Statistical Reporting Service, 1972-1982. 1982 American Statistical Association Meetings (Cincinnati, Ohio), Aug. 1982.

6-24. Craig, M. E.: Area Estimates by Landsat, Arizona 1979. Statistical Research Division; Economics, Statistics and Cooperatives Service, USDA (Washington, D.C.), 1980.

- 6-25. Erickson, W.: The Microcomputer Work Station: An Alternative Hardware Architecture for Digital Image Processing. Eighth William T. Pecora Memorial Remote Sensing Symposium (Sioux Falls, S. Dak.), Oct. 1983.
 - 6-26. Hanuschak, G., and C. Caudill: Management Issues of Integrating Earth Resource Satellite Data Into the United States Department of Agriculture's Domestic Crop-Area Estimation Program. 1983 Meeting of the Institute of Management Science/Operations Research Society of America (Orlando, Fla.), Nov. 1983.
 - 6-27. Hanuschak, G., R. Allen, and W. Wigton: Integration of Landsat Data Into the Crop Estimation Program of USDA's Statistical Reporting Service, 1972-1982. Eighth Int. Symposium on Machine Processing of Remotely Sensed Data, Purdue Univ. (W. Lafayette, Ind.), July 8, 1982.
 - 6-28. Hofman, L. B., W. K. Erickson, and W. E. Donovan: MIDAS: A Microcomputer-Based Image Display and Analysis System With Full Landsat Frame Processing Capabilities. Seventeenth Int. Symposium on Remote Sensing of the Environment (Ann Arbor, Mich.), May 1983.
 - 6-29. Holko, M.: 1982 USDA Results for the California Cooperative Remote Sensing Project. Statistical Reporting Service, USDA (Washington, D.C.), 1984.
 - 6-30. Kleweno, D. D., and C. E. Miller: 1980 AgRISTARS DC/LC Project Summary Crop Area Estimates for Kansas and Iowa. ESS Staff Rep. AGESS 810414, Mar. 1981.
 - 6-31. May, G.: Evolution of Land Cover Definitions and Survey for the Economics and Statistics Service. June 1981.
 - 6-32. May, G., and R. Allen: Non-Sampling Errors in Non-Agricultural Strata of the 1980 Kansas June Enumerative Survey. Oct. 1981.
 - 6-33. May, G., and D. Kleweno: 1981 Kansas Land Cover Survey Manual. ESS Research Division (Washington, D.C.).
 - 6-34. May, G., M. Holko, and E. Jones: State Level Landsat Classification and Area Estimates of Major Crops and Land Covers in Missouri. 1983.
 - 6-35. Mergerson, J. W.: Crop Area Estimates Using Ground-Gathered and Landsat Data. ESS Staff Rep. AGESS 810223, Feb. 1981.
 - 6-36. Mergerson, J. W.: Crop Area Estimation Using Ground-Gathered and Sampled Landsat Data. ESS Staff Rep. AGESS 810408, May 1981.
 - 6-37. Mergerson, J., G. Hanuschak, and P. Cook: Applications of Satellite Remote Sensing for U.S. Crop Acreage Estimation, 1980-81 Results. Sixteenth Int. Symposium on Remote Sensing of the Environment (Ann Arbor, Mich.), May 1982.
 - 6-38. Mergerson, J., V. B. Johnson, and R. A. Kestle: AgRISTARS DC/LC Applications Project: 1982 Winter Wheat Area Estimates for Colorado, Kansas and Oklahoma. Ninth Int. Symposium on Machine Processing of Remotely Sensed Data, Purdue Univ. (W. Lafayette, Ind.), June 1983.
 - 6-39. Mergerson, J., C. Miller, M. Ozga, M. Holko, S. Winings, P. Cook, and G. Hanuschak: 1981 AgRISTARS DC/LC Four State Project. Eighth Int. Symposium on Machine Processing of Remotely Sensed Data, Purdue Univ. (W. Lafayette, Ind.), July 1982.
 - 6-40. Mergerson, J., S. Winings, P. Cook, V. Johnson, G. May, M. Holko, and R. Kestle: 1983 AgRISTARS DC/LC Large Scale Crop Acreage Estimation Project. Statistical Reporting Service, USDA (Washington, D.C.), 1984.
 - 6-41. Ozga, M., and R. Sigman: An Autodigitizing Procedure for Ground-Data Labeling of Landsat Pixels. Fifteenth Int. Symposium on Remote Sensing of the Environment (Ann Arbor, Mich.), May 1981.
 - 6-42. Ryerson, R. A., R. S. Sigman, and R. J. Brown: Satellite Remote Sensing for Domestic Crop Reporting in the United States and Canada: A Look to the Future. Seventh Canadian Symposium on Remote Sensing (Winnipeg, Manitoba), Sept. 9, 1981.
 - 6-43. Sigman, R.: Crop Area Estimate From Landsat and Ground Survey Data. Canadian Federal Provincial Committee on Agriculture Statistics (Ottawa, Canada), Mar. 1980.
 - 6-44. Sigman, R., and M. Craig: Potential Utility of Thematic Mapper Data in Estimating Crop Areas. Fifteenth Int. Symposium on Remote Sensing of the Environment (Ann Arbor, Mich.), May 1981.
 - 6-45. Sigman, R., and G. Walker: Comparison of Auxiliary Variables for Satellite-Data Regression Estimators in Crop Surveys. Proc. Section on Survey Research Methods, 1983 American Statistical Association Meetings (Washington, D.C.), Sept. 1983.
 - 6-46. Walker, G., and R. Sigman: County-Level Crop Area Estimates From Landsat: Evaluation of the Battese-Fuller Estimator. Proc. Section on Survey Research Methods, 1982 American Statistical Association Meetings (Washington, D.C.), 1982.
 - 6-47. Walker, G., and R. Sigman: Evaluation of the Huddleston-Ray and Battese-Fuller Estimators. ESS Staff Rep. AGESS-820909, Statistical Reporting Service, USDA (Washington, D.C.), Sept. 1982.
 - 6-48. Winings, S. B.: Estimating Potatoes and Other Crops in the Red River Valley of North Dakota and Minnesota Using 1980 Landsat Imagery. ESS Staff Rep. AGESS 810519, May 1981.
 - 6-49. Winings, S.: Landsat Image Availability of Crop Area Estimation. Eighth Int. Symposium on Machine Processing of Remotely Sensed Data, Purdue Univ. (W. Lafayette, Ind.), Statistical Reporting Service, USDA (Washington, D.C.), July 1982.
 - 6-50. Winings, S., P. Cook, and G. Hanuschak: AgRISTARS DC/LC Applications Project: 1982 Corn and Soybeans Area Estimates for Iowa and Illinois. Seventeenth Int. Symposium on Remote Sensing of the Environment (Ann Arbor, Mich.), May 1983.
 - 6-51. Zuttermeister, J. P., and R. Sigman: The Effect of Cubic Convolution Resampling on Crop Area Estimates. ESS Staff Rep. AGESS-831209, Statistical Reporting Service, USDA (Washington, D. C.), Dec. 1983.
7. RRI Reports
- 7-01. Use and Evaluation of the Vegetation Component of Recommended National Land Classification System for Renewable Resource Assessment Progress Report. RR-L0-R0447, LEMSCO-14856, Apr. 1980.
 - 7-02. Use and Evaluation of the Vegetation Component of the National Site (Land) Classification System. RR-L0-R0466, LEMSCO-15173, July 1980.

7-03. An Evaluation of ISOCLS and CLASSY Clustering Algorithms for Forest Classification in Northern Idaho. RR-L0-R0473, LEMSCO-15318, July 1980.

7-04. Analysis of Forest Classification Accuracy. RR-VPI0-R0485, Jan. 1981.

7-05. Sensor Parameter Study Literature Review and Experimental Plan. RR-G0-04009, Oct. 1980.

7-06. Nationwide Forestry Applications Program RRI Project - Final Report - Detection and Measurement of Changes in the Production and Quality of Renewable Resources. RR-E1-04034, USDA Forest Service, 53-3187-9-47, Sept. 30, 1980.

7-07. Nationwide Forestry Applications Program Cooperative Research Report. Analysis of Forest Classification Accuracy. RR-U1-04066, JSC-17123, Jan. 1981.

7-08. Interim Report: Effects of Forest Canopy Closure on Incoming Solar Radiance. RR-G1-04085, Apr. 1981.

7-09. Objectives in Issues for Use in Developing Various Detailed Aspects of a Land Information Support System: A Summary of Discussions Through April 1981. RR-L1-04110, LEMSCO-16670, Apr. 1981.

7-10. Final Report: An Evaluation of ISOCLS and CLASSY Clustering Algorithms for Forest Classification in Northern Idaho. RR-L1-04143, JSC-17418, LEMSCO-17154, Sept. 1981. NTIS: 82N21650.

7-11. Final Report: San Juan National Forest Land Management Planning Support System (LMPSS) Requirements Definition. RR-I1-04146, JSC-17422, LEMSCO-17163, Sept. 1981. NTIS: 82N21649.

7-12. Evaluation of VICAR Software Capability for Land Information Support System Needs. RR-L1-04171, JSC-17431, LEMSCO-17269, Sept. 1981. NTIS: 82N23596.

7-13. Analysis of Thematic Mapper Simulator Data Acquired During Winter Season Over Pearl River, Mississippi, Test Site. RR-Y1-04217, Mar. 1982. NTIS: 82N24565.

7-14. Detecting Forest Canopy Change Using Landsat. RR-G2-04258, Apr. 1982.

7-15. Semi-Annual Program Review Presentation to Level 1, Interagency Coordination Committee. RR-J2-04272, JSC-17832, Apr. 19, 1982.

7-16. Final Report: Data Base Manipulation for Assessment of Multiresource Suitability and Land Change. RR-E2-04293, USDA-Forest Service 53-3187-1-38, Sept. 1981.

7-17. Photographic Technology Development Project: Timber Typing in the Tahoe Basin Using High Altitude Panoramic Photography: Final Report. Nationwide Forestry Applications Program. LEMSCO-15691, June 1981.

7-18. Final Report: Development and Testing of Landsat Assisted Procedures for Cost Effective Forest Management. RR-E2-04368, 53-3187-2-24, Sept. 1982.

7-19. Semi-Annual Program Review Presentation to Level 1. Interagency Coordination Committee. RR-U2-04380, JSC-18583, Nov. 1982.

Plans

7-20. Land Information Support System Implementation Plan and Schedule. RR-L1-00641, JSC-17434, Oct. 1981. NTIS: 82N23597.

Unnumbered Documents

7-21. Allen, R.: The AgRISTARS Research Program. Federal-Provincial Committee on Agricultural Statistics (Ottawa, Canada), Mar. 11, 1980.

7-22. Allen, R.: A Federal User of Landsat Remote Sensing. Western Regional Remote Sensing Conf., (Monterey, Calif.), Mar. 30, 1981.

7-23. Caudill, C. E., and R. C. McArdle: Research Evaluation Considerations for AgRISTARS. Third Conference on Economics of Remote Sensing (Lake Tahoe, Nevada), Nov. 1979.

7-24. Caudill, C. E., R. Allen, D. Tarpley, and G. Hart: Presentation to Washington Statistical Society. AgRISTARS, Apr. 15, 1980.

7-25. Larsen, G. A., and W. C. Iwig: Evaluation of Plant Process Models Using AgRISTARS Criteria. Crop Simulation Workshop (Gainesville, Fla.), Mar. 1981.

7-26. Final Report - Detection and Measurement of Changes in the Production and Quality of Renewable Resources. ERIM, Sept. 1980.

7-27. Final Report - Methods for Determination of REU Survey Plot and County Boundary Coordinates. R. F. Liston, USDA Forest Service, Sept. 1980.

7-28. ISOCLS and CLASSY. Seventh Annual Symposium on Machine Processing of Remotely Sensed Data, Purdue Univ. (W. Lafayette, Ind.), 1981.

7-29. Multiresource Inventory Methods Pilot Test. American Soc. Photogrammetry Meeting, Feb. 25, 1981.

7-30. Multiresource Inventory Methods Pilot Test (Phase 1), Evaluation of Multiresource Analysis and Information System Processing Components, Kershaw County, SC, Feasibility Test. ESC, Sept. 1980.

7-31. Multiresource Inventory Methods Pilot Test (Phase 1), Final Report. ESC, Oct. 1980.

7-32. Multiresource Inventory Methods Pilot Test (Phase 1), Multiresource Analysis and Information System Concept Development. ESC, June 1980.

7-33. Multiresource Inventory Methods Pilot Test (Phase 1), Multiresource Inventory Design and Sampling Network. ESC, June 1980.

7-34. Multiresource Inventory Methods Pilot Test (Phase 2), Implementation Plan. ESC, Sept. 1980.

7-35. Nelson, R., R. Latty, and G. Mott: Classifying Northern Forests Using Thematic Mapper Simulation Data. Photogrammetric Eng. and Remote Sensing, 1984, (in press).

7-36. A Pilot Test of High Altitude Optical Bar Camera Photography to Estimate Annual Mortality of Ponderosa Pine Caused by the Mountain Pine Beetle in Colorado. LEMSCO-14308, Mar. 1980.

8. C/P

Reports

8-01. Ritchie, J. C.: Conservation Pollution Implementation Plan FY 1982. CP-J2-C0656, JSC-18565, 1982.

8-02. Research for Reliable Quantification of Water Sediment Concentrations From Multispectral Scanner Remote Sensing Data. CP-Z1-04078, JSC-17134, May 1981.

8-03. A Comparison of Observed and Analytical Derived Remote Sensing Penetration Depths for Turbid Water. CP-Z1-04149, NASA TM 83176, Sept. 1981.

8-04. Strategies for Using Remotely Sensed Data in Hydrologic Models. CP-G1-04151, July 1981.

8-05. Mineralogical, Optical, and Geochemical Properties of John H. Kerr Reservoir Sediment Samples for AgRISTARS Pollution Research. CP-Z1-04177, NAS 1-16042, Aug. 1981. NTIS: 81N33568.

8-06. Determination of Turbidity Patterns in Lake Chicot from Landsat MSS Imagery. CP-32-04238, Nov. 1981.

8-07. Determination of Circulation and Turbidity Patterns in Kerr Lake from Landsat MSS Imagery. CP-32-04238, Nov. 1981. NTIS: 82N24551.

8-08. Criteria for the Use of Regression Analysis for Remote Sensing of Sediment and Pollutants. CP-Z2-04239, Feb. 1982. NTIS: 82N24543.

8-09. Semi-Annual Program Review Presentation to Level 1, Interagency Coordination Committee. CP-U2-04275, Apr. 20, 1982.

8-10. Laboratory Upwelled Radiance and Reflectance Spectra of Kerr Reservoir Sediment Waters. CP-Z2-04294, Mar. 1982. NTIS: 82N21774.

8-11. Laboratory Measurements of Physical, Chemical, and Optical Characteristics of Lake Chicot Sediment Waters. CP-Z2-04295, Dec. 1981.

8-12. Calibration of a Turbidity Meter for Making Estimates of Total Suspended Solids Concentrations and Beam Attenuation Coefficients in Field Experiments. CP-Z2-04307, Oct. 1981.

8-13. Kerr Reservoir Landsat Experiment Analysis for November 1980. CP-32-04324, NAS 1-16000, May 1982.

8-14. Kerr Reservoir Landsat Experiment Analysis for March 1981. CP-32-04333, NAS 1-16000, July 1982.

8-15. Mineralogical, Optical, and Geochemical Properties of John H. Kerr Reservoir and Lake Chicot Sediment Samples for AgRISTARS Pollution Research. CP-Z2-04338, NAS 1-16042, Aug. 1981.

8-16. Wilkeing, H. A., III, and R. M. Ragan: A Model for Estimating Time-Variant Rainfall Infiltration as a Function of Antecedent Surface Moisture and Hydrologic Soil Type. CP-52-04372, Univ. of Md., Oct. 1982.

8-17. Wilkeing, H. A., III: Sensitivity of Rainfall Excess to Antecedent Soil Moisture and Soil Hydraulic Properties. CP-52-04373, Univ. of Md. Oct. 1982.

8-18. The Desorptivity Model of Bulk Soil-Water Evaporation. CP-53-04416, Apr. 1983.

8-19. The Continuous Similarity Model of Bulk Soil-Water Evaporation. CP-53-04417, Apr. 1983.

8-20. Snow Run-Off Simulation Using the Martinac-Range Model on the South Fork Rio Grande and Conejos River in Colorado. CP-G1-04072, Feb. 1981.

8-21. Review of Hydrologic Models for Evaluating Use of Remote Sensing Capabilities. CP-G1-04102, Mar. 1981.

8-22. Remote Sensing and Hydrologic Model. CP-G2-04249, Mar. 1982.

8-23. Near Surface Regional Ground Water Systems Modeling and Potential Application for Remote Sensing. CP-G2-04361. Oct. 1981.

8-24. Combining Remotely Sensed and Other Measurements for Hydrologic Areal Averages. CP-G2-04382, Oct. 1982.

Plans

8-25. Conservation and Pollution Implementation Plan. CP-J1-C0621, JSC-17110, 1981.

8-26. Conservation and Pollution Implementation Plan. CP-J1-C0625, JSC-17148, 1980.

8-27. Conservation and Pollution Plan for Fiscal Years 1982 and 1983. CP-J1-C0643, JSC-17439, Oct. 1981.

8-28. Conservation and Pollution Project Implementation Plan for Fiscal Year 1983. CP-U2-C0656, JSC-18565, Sept. 1982.

Unnumbered Documents

8-29. Barnes, J. C.: Survey Paper on Remote Sensing Techniques to Map Snow Cover. Int. Geoscience and Remote Sensing Symposium (Washington, D.C.), June 1981.

8-30. Barnes, W. L., and J. C. Price: Calibration of a Satellite Infrared Radiometer. J. Appl. Optics, vol. 19, 1980, pp. 2153-2161.

8-31. Bondelid, T. R., T. J. Jackson, and R. H. McCuen: Comparison of Conventional and Remotely Sensed Estimates of Runoff Curve Numbers in Southeastern Pennsylvania. Proc. Annual Meeting of American Soc. Photogrammetry (St. Louis, Mo.), 1980.

8-32. Bondelid, T. R., T. J. Jackson, and R. H. McCuen: A Computer Based Approach to Estimating Runoff Curve Numbers Using Landsat Data. Univ. of Md. (College Park), 1980.

8-33. Bondelid, T. R., T. J. Jackson, and R. H. McCuen: Estimating Runoff Curve Numbers Using Remote Sensing Data. Int. Symposium on Rainfall-Runoff Modeling, Miss. State Univ., 1981.

8-34. Brakensiek, D. L., and W. J. Rawls: Agricultural Management Effects on Soil Water Processes: Part II, Green-Ampt Parameters for Crusted Soils. Trans. American Soc. Agric. Eng., 1983.

8-35. Brakensiek, D. L., and W. J. Rawls: An Infiltration Based Rainfall-Runoff Model for SCS Type II Distribution. Trans. American Soc. Agric. Eng., vol. 25, no. 6, 1982, pp. 1607-1611.

8-36. Brakensiek, D. L., and W. J. Rawls: Green-Ampt Infiltration Model Parameters for Hydrologic Classification of Soils. Proc. American Soc. Civil Eng., Irrigation and Drainage Conf. (Jackson Hole, Wyo.), 1983.

8-37. Brakensiek, D. L., R. L. Engleman, and W. J. Rawls: Variation Within Texture Classes of Soil Water Parameters (accepted for publication in Trans. American Soc. Agric. Eng.).

8-38. Brakke, T. W., and Kanemasu, E.: Isolation Estimations from Satellite Measurement of Reflected Radiation. Satellite Forecast Workshop (Washington, D.C.), sponsored by Solar Energy Research Institute, Feb. 1981.

8-39. Chang, A. T. C., and A. Rango: Remote Sensing Applications in Snow Hydrology - Past, Present and Future. Proc. of the Fiftieth Annual Western Snow Conf. (Reno, Nev.), 1982, pp. 204-207.

8-40. Chang, A. T. C., and J. Shiue: A Comparative Study of Microwave Radiometer Observations Over Snowfields With Radiative Transfer Model Calculations. NASA TM 80267. Remote Sensing of Environment (in press).

- 8-41. Chang, A. T. C., J. Shiue, and A. Rango: Remote Sensing of Snow Properties by Passive Microwave Radiometry: GSFC Truck Experiment. NASA Microwave Snow Property Workshop, NASA CP-2153, 1980.
- 8-42. Chang, A. T. C., J. L. Foster, D. K. Hall, and A. Rango: Monitoring Snowpack Properties by Passive Microwave Sensors on Board Aircraft and Satellite. NASA Microwave Snow Property Workshop, NASA CP-2153, 1980.
- 8-43. Chang, A. T. C., J. L. Foster, D. K. Hall, A. Rango, and B. K. Hartline: Snow Water Equivalent Estimation by Microwave Radiometry. *Cold Regions Sci. and Technology*, vol. 5, 1982, pp. 259-267.
- 8-44. Chang, A. T. C., J. L. Foster, M. Owe, D. K. Hall, and A. Rango: Passive and Active Microwave Studies of Snowpack Properties - Results of March 4, 1981 Aircraft Mission, 1983 (submitted for publication).
- 8-45. Cooley, K. R.: Evaporation Reduction: Summary of Long-Term Tank Studies. *J. Irrigation and Drainage Div., American Soc. Civil Eng.*, vol. 109, no. IR1, March 1983, pp. 89-98.
- 8-46. Cooley, K. R.: Report on Quality of Watershed Data from Hawaii Small Watershed Project. USDA-ARS, ARM-W-31, Aug. 1982, pp. 43-49.
- 8-47. Cooley, K. R., and L. J. Lane: Modified Runoff Curve Numbers for Sugarcane and Pineapple Fields in Hawaii. *J. Soil and Water Conserv.*, vol. 37, no. 5, Sept.-Oct. 1983, pp. 295-298.
- 8-48. Cooley, K. R., and L. J. Lane: Optimized Runoff Curve Numbers for Sugarcane and Pineapple Fields in Hawaii. *J. Soil and Water Conserv.*, vol. 35, no. 3, May-June 1980, pp. 137-141.
- 8-49. Cooley, K. R., and D. C. Robertson: Monitoring a Rain on Snow Event. *Proc. Western Snow Conf.* (Vancouver, Wash.), Apr. 1983, pp. 19-26.
- 8-50. Cooley, K. R., and J. R. Williams: Applicability of USLE and MUSLE to Hawaiian Agricultural Lands. *Proc. Symposium on Soil Erosion and Conservation*, Jan. 1983.
- 8-51. Cooley, K. R., E. P. Springer, and A. L. Huber: SPUR: The Hydrology Component; Snowmelt. USDA-ARS, Misc. publ. no. 1431, Feb. 1983, pp. 45-61.
- 8-52. Davis, R., and D. Marks: Undisturbed Measurement of the Energy and Mass Balance of a Deep Alpine Snowcover. *Proc. Forty-Eighth Western Snow Conf.*, 1980, pp. 62-67.
- 8-53. Dey, B., D. C. Goswami, and A. Rango: Utilization of Satellite Snow-Cover Observations for Seasonal Streamflow Estimates in the Western Himalayas. *Nordic Hydrology*, vol. 15, 1984.
- 8-54. Dozier, J.: A Clear Sky Spectral Solar Radiation Model for Snow-Covered Mountainous Terrains. Seminar NASA/GSFC (Greenbelt, Md.), sponsored by Laboratory for Atmospheric Sciences, Nov. 1980.
- 8-55. Dozier, J.: Satellite-Derived Estimates of Net All-Wave Radiation Over an Alpine Snow Cover. A.G.U. (San Francisco, Calif.), Fall 1980.
- 8-56. Dozier, J.: Satellite Identification of Surface Radiant Temperature Fields of Subpixel Resolution. Tech. Memo NESS 113, NOAA, 1980.
- 8-57. Dozier, J.: Use of Environmental Satellite Data for Input to Energy Balance Snowmelt Models. Final Rep. NOAA Grant 04-8-MO, 1980.
- 8-58. Engman, E. T.: Agriculture Needs Related to Satellite Hydrology. *Proc. American Water Resources Assoc. Percora, Symposium* (Sioux Falls, S. Dak.), 1979 (in press).
- 8-59. Engman, E. T.: Remote Sensing Applications in Hydraulic Modeling. Keynote paper for Int. Symposium on Rainfall-Runoff Modeling, Miss. State Univ. (in press).
- 8-60. Foster, J. L., D. K. Hall, A. T. C. Chang, and A. Rango: An Overview of Passive Microwave Snow Research and Results. *Reviews of Geophysics and Space Physics*, vol. 22, 1984.
- 8-61. Foster, J. L., D. K. Hall, A. Rango, A. T. C. Chang, L. J. Allison, and B. C. Diesen: The Influence of Snow Depth and Surface Air Temperature on Satellite-Derived Microwave Brightness Temperature. NASA Tech. Memo. 80695, 1980.
- 8-62. Foster, J. L., A. Rango, D. K. Hall, A. T. C. Chang, L. J. Allison, and B. C. Diesen: Snowpack Monitoring in North America and Eurasia Using Passive Microwave Satellite Data. Remote Sensing of Environment (in press).
- 8-63. Frampton, M., and D. Marks: Mapping Snow Surface Temperature From Thermal Satellite Data in the Southern Sierra. *Proc. Forty-Eighth Western Snow Conf.*, 1980, pp. 88-96.
- 8-64. Frew: Remote Sensing of Snow Surface Albedo. Final Rep. NOAA Grant 04-8-MO, Use of Environmental Satellite Data for Input to Energy Balance Snowmelt Models, 1980.
- 8-65. Groves, J. R., and R. M. Ragan: Development and Testing of a Remote Sensing Based Continuous Streamflow Model. Hydrological Applications of Remote Sensing and Remote Data Transmission. *Proc. Hamburg Symposium*, Aug. 1983, IAHS Publ., 1983.
- 8-66. Groves, J. R., and R. M. Ragan: The Structuring of a Remote Sensing Based Continuous Streamflow Model. Remote Sensing of Environment, 1983 (in press).
- 8-67. Haan, C. T., D. L. Brakensiek, H. P. Johnson, eds.: Monograph on Hydrologic Modeling of Small Watersheds. American Soc. Agric. Eng., Mar. 1980.
- 8-68. Hall, D. K., J. L. Foster, and A. T. C. Chang: Measurement and Modeling of Microwave Emission From Forested Snowfields in Michigan. *Nordic Hydrology*, vol. 13, 1982, pp. 129-138.
- 8-69. Hall, D. K., J. L. Foster, and A. T. C. Chang: Nimbus-7 SMMR Polarization Responses to Snow Depth in the Mid-Western United States. 1983 (submitted for publication).
- 8-70. Hall, D. K., A. Rango, J. L. Foster, and A. T. C. Chang: Progress and Requirements of Passive Microwave Remote Sensing of Snowpack Properties. *Proc. Workshop on Polar Surface Micro Properties for Climate Research* (Greenbelt, Md.), 1980.
- 8-71. Hanson, C. L., E. L. Neff, and A. D. Nicks: Estimating SCS Runoff Curve Numbers on Native Grazing Lands. CREAMS: A Field Scale Model for Chemicals, Runoff, and Erosion From Agricultural Management Systems, W. G. Knisel, ed. USDA, SEA Conserv. Res. Rep. 26, May 1980, pp. 398-404.
- 8-72. Hanson, C. L., E. L. Neff, J. T. Doyle, and T. L. Gilbert: Runoff Curve Numbers for Northern Great Plains Rangelands (submitted for publication in *J. Soil and Water Conserv.*).

- 8-73. Hawley, M. E., R. H. McCuen, and A. Rango: Comparison of Models for Forecasting Snowmelt Runoff Volumes. *Water Resources Bull.*, vol. 16, no. 5, 1980, pp. 914-920.
- 8-74. Idso, S. B., and K. R. Cooley: Meteorological Modification of Particulate Air Pollution and Visibility Patterns at Phoenix, Arizona (accepted for publication in *Archives Fur. Met., Geophys., and Bioclimate*).
- 8-75. Jackson, T. J.: Profile Soil Moisture From Surface Measurements. *J. Irrigation and Drainage Div., American Soc. Civil Eng.*, vol. 106, no. 1R2, 1980, pp. 81-92.
- 8-76. Jackson, T. J., and W. J. Rawls: SCS Urban Curve Numbers From a Landsat Data Base. 1980 (accepted for publication in *Water Resources Bull.*).
- 8-77. Jackson, T. J., T. J. Schmugge, A. D. Nicks, G. A. Coleman, and E. T. Engman: Soil Moisture Updating and Microwave Remote Sensing for Hydrologic Simulation. *Hydrol. Sciences Bull.*, 1980.
- 8-78. Jackson, T. J., T. J. Schmugge, G. A. Coleman, C. R. Richardson, A. T. C. Chang, J. Wang, and E. T. Engman: Aircraft Remote Sensing of Soil Moisture and Hydrologic Parameters, Chickasha, Oklahoma, and Riesel, Texas. 1978 Data Report, ARR-NE-8, USDA, SEA-AR (Beltsville, Md.), 1980.
- 8-79. Johnson, E. R., E. L. Peck, and T. N. Keefer: Combining Remote Sensed and Other Measurements for Hydrologic Areal Averages. NASA Contractor Report 170457 (Greenbelt, Md.), 1982.
- 8-80. Johnson, C. W., C. L. Hanson, G. R. Stephenson, and K. R. Cooley: Report on Quality of Watershed and Plot Data from the Northwest Watershed Research Center, Boise, Idaho. USDA-ARS, ARM-W-31, Aug. 1982, pp. 50-59.
- 8-81. Johnson, C. W., G. M. Secrist, G. C. Scholten, and R. J. Baum: Watershed Management in Action on the Boise Front. *Proc. American Soc. Civil Eng. Watershed Management Symposium* (Boise, Idaho), 1980, pp. 998-1011.
- 8-82. Jones, E. B., A. Rango, and S. M. Howell: Snowpack Liquid Water Determinations Using Freezing Calorimetry. *Nordic Hydrology*, vol. 14, 1983.
- 8-83. Jones, E. B., D. M. Frick, B. A. Shafer, and A. Rango: Snowmelt Runoff Modeling Using Landsat Imagery. *Proc. Specialty Conference on Advances in Irrigation and Drainage: Surviving External Pressures*, ASCE (Jackson, Wyo.), 1983, pp. 484-493.
- 8-84. LeCroy, S. R.: Determination of Turbidity Patterns in Lake Chicot from Landsat MSS Imagery. NASA Contractor Report 165870, Langley Research Center (Hampton, Va.), 1982.
- 8-85. Lillesand, T. M., D. E. Meisner, A. L. Downs, and R. L. Peuell: Satellite Monitoring of Snow Extent and Condition in Agricultural, Transitional, and Forested Land Cover Areas. Final Rep. NOAA Grant NA80AA-D-0019, 1980.
- 8-86. Marks, B., and D. Marks: Areal Determination of the Influence of a Forest Canopy on the Surface Radiant Energy Exchange. *Proc. Forty-Eighth Western Snow Conf.*, 1980, pp. 43-49.
- 8-87. Martinec, J., A. Rango, and E. Major: The Snowmelt-Runoff Model (SRM) User's Manual. NASA Reference Publication 1100 (Washington, D. C.), 1983.
- 8-88. McCuen, R. H., W. J. Rawls, and D. L. Brakensiek: Statistical Analysis of the Brooks-Corey and the Green-Ampt Parameters Across Soil Textures (submitted for publication in *Water Resources Res.*).
- 8-89. Moore, D. G.: Thermal Infrared for Monitoring Soil and Rainfall Distribution, NOAA/NESS Research and Development, May 1981.
- 8-90. Moore, D. G.; and Heilman, J. L.: Thermal Infrared for Monitoring Soil and Rainfall Distribution, International Geoscience and Remote Sensing Symposium, (Washington, D.C.), June 1981.
- 8-91. Morris, W. D., W. G. Wille, Jr., and C. H. Whitlock: Turbid Water Measurements of Remote Sensing Penetration Depth at Visible and Near Infrared Wavelengths. *Proc. Symposium on Surface-Water Impoundments* (Minneapolis, Minn.), 1980.
- 8-92. Narasimhan, V. A., A. L. Huber, J. P. Riley, and J. J. Jurinak: Development of Procedures to Evaluate Salinity Management Strategies in Irrigation Return Flows. Rep. UWRL/P-80-03, Utah Water Res. Lab., June 1980.
- 8-93. Nicks, A. D., and J. F. Harp: Stochastic Generation of Temperature and Solar Radiation Data. *J. Hydrology*, vol. 48, no. 1, 1980, pp. 1-17.
- 8-94. Nicks, A. D., L. C. Miller, G. A. Gander, and Y. K. Yang: Estimating Dry Matter Production and Yield From Wheat and Rangeland Using Hydrologic Models and Landsat Data. *American Geophys. Union Western Annual Meeting* (San Francisco, Calif.), Dec. 8-12, 1980.
- 8-95. Owe, M., and J. P. Ormsby: Improved Classification of Small Scale Urban Watersheds Using Thematic Mapper Simulator Data. *Int. J. of Remote Sensing*, 1984 (in press).
- 8-96. Peck, E. L., E. R. Johnson, and T. N. Keefer: Creating a Bridge Between Remote Sensing and Hydrologic Models. NASA Contractor Report 170517, (Greenbelt, Md.), 1983.
- 8-97. Peck, E. L., E. R. Johnson, T. N. Keefer, and A. Rango: Combining Measurements of Hydrological Variables of Various Sampling Geometries and Measurement Accuracies. *Hydrological Applications of Remote Sensing and Remote Data Transmission. Proc. Hamburg Symposium*, Aug. 1983, IAHS-AISH publication, Int. Assoc. Hydrological Sci. (Hamburg, FRG), 1984.
- 8-98. Price, J. C.: The Contribution of Thermal Data in Landsat Multispectral Classification. *Photogrammetric Eng. and Remote Sensing*, vol. 47, 1981, pp. 229-236.
- 8-99. Price, J. C.: The Potential of Remotely Sensed Thermal Infrared Data to Infer Surface Soil Moisture and Evaporation. *Water Resources Res.*, vol. 16, 1980, pp. 787-795.
- 8-100. Price, J. C., and Galli de Paratesi, Dr. S.: Heat Capacity Mapping Mission. Meeting of the Experiment Team of the Satellite Program and the Tellus Program of the European Community at the Joint Research Center of the European Communities (Ispra, Italy), Mar. 25-28, 1980.
- 8-101. Price, J. C., and J. D. Lin: Guidelines for the Hydrologic Processes Special Study - An Element of the NASA Climate Research Program. Univ. of Conn., 1980.
- 8-102. Ragan, R. M.: Remote Sensing in Hydrologic Investigations. *Int. Seminar on Benefits of Remote Sensing for National Development*. Cosponsored by United Nations and Food and Agric. Org. (San Jose, Costa Rica), Apr. 20-22, 1980.

- 8-103. Ragan, R. M., and M. Calabrese: Renewable Resource Applications of Remote Sensing in the 1980's. Proc. 1980 Annual Meeting American Astronaut. Soc. (Boston, Mass.), Oct. 1980.
- 8-104. Ragan, R. M., and J. D. Fellows: A Data Base System for Real Time Hydrologic Modeling. Proc. Civil Eng. Applications of Remote Sensing Specialty Conf., American Soc. Civil Eng. (Madison, Wisc.), Aug. 1980.
- 8-105. Ragan, R. M., and J. D. Fellows: An Overview of Remote Sensing Based Regional Information Systems for Hydrologic Modeling. Proc. Fourteenth Int. Symposium on Remote Sensing of the Environment (San Jose, Costa Rica), Apr. 1980.
- 8-106. Ragan, R. M., and T. J. Jackson: Runoff Synthesis Using Landsat and the SCS Models. J. Hydraulics Div., American Soc. Civil Eng., vol. 106, no. HYS, 1980, pp. 667-678.
- 8-107. Rango, A.: Application of a Simple Snowmelt-Runoff Model to Large River Basins. Proc. Fifty-First Annual Western Snow Conf., (Vancouver, Wash.), 1983, pp. 89-99.
- 8-108. Rango, A.: Hydrological Research in the AgRISTARS Program. Hydrological Applications of Remote Sensing and Remote Data Transmission. Proc. Hamburg Symposium, Aug. 1983, IAHS-AISH publication, Int. Assoc. of Hydrological Sci. (Hamburg, FRG), 1984.
- 8-109. Rango, A.: Operational Applications of Remote Sensing for Snow Hydrology. Proc. Symposium on the Application of Remote Sensing to Resource Management, ASP (Seattle), 1983.
- 8-110. Rango, A.: Operational Applications of Satellite Snow Cover Observation. Water Resources Bull., vol. 16, no. 6, 1980.
- 8-111. Rango, A.: Remote Sensing of Snow Covered Area for Runoff Modeling. Hydrological Forecasting, Proc. Oxford Symposium. IAHS-AISH publication no. 129. Int. Assoc. Sci. Hydrology (Oxford, U.K.), 1980, pp. 291-297.
- 8-112. Rango, A.: A Survey of Progress in Remote Sensing of Snow and Ice. Hydrological Applications of Remote Sensing and Remote Data Transmission. Proc. Hamburg Symposium, Aug. 1983, IAHS-AISH publication, Int. Assoc. Hydrological Sci. (Hamburg, FRG), 1984.
- 8-113. Rango, A., and J. Martinec: Application of a Snowmelt-Runoff Model Using Landsat Data. Nordic Hydrology, vol. 10, 1979, pp. 225-238.
- 8-114. Rango, A., and J. Martinec: Snow Accumulation Derived From Modified Depletion Curves of Snow Coverage. Hydrological Aspects of Alpine and High Mountain Areas. Proc. Exeter Symposium. IAHS-AISH publication no. 138, Int. Assoc. Hydrological Sci. (Exeter, U.K.), 1982, pp. 83-90.
- 8-115. Rango, A., and R. Peterson: Operational Applications of Satellite Snowcover Observations. NASA Conf. Publ. CP-2116, NASA Headquarters (Washington, D.C.), 1980, 302 pp.
- 8-116. Rango, A., A. T. C. Chang, and J. L. Foster: The Utilization of Spaceborne Microwave Radiometers for Monitoring Snowpack Properties. Nordic Hydrology, vol. 10, 1979, pp. 25-40.
- 8-117. Rango, A., A. Feldman, T. George, and R. Ragan: Effective Use of Landsat Data in Hydrologic Models. Water Resources Bull., vol. 19, no. 2, 1983, pp. 165-174.
- 8-118. Rango, A., J. Martinec, J. Foster, and D. Marks: Resolution in Operational Remote Sensing of Snow Cover. Hydrological Applications of Remote Sensing and Remote Data Transmission. Proc. Hamburg Symposium, Aug. 1983, IAHS-AISH publication, Int. Assoc. Hydrological Sci. (Hamburg, FRG), 1984.
- 8-119. Rawls, W. J., and D. L. Brakensiek: Estimating Soil Water Retention From Soil Properties. J. Irrigation and Drainage Div., American Soc. Civil Eng., vol. 108, no. IR2, 1982, pp. 166-171.
- 8-120. Rawls, W. J., and D. L. Brakensiek: A Procedure to Predict Green and Ampt Infiltration Parameters. American Soc. Agric. Eng., Proc. of Advances in Infiltration Conf. (Chicago, Ill.), 1983.
- 8-121. Rawls, W. J., D. L. Brakensiek, and N. Miller: Predicting Green and Ampt Infiltration Parameters From Soils Data. J. Irrigation and Drainage Div., American Soc. Civil Eng., vol. 109, no. IR1, 1983, pp. 62-70.
- 8-122. Rawls, W. J., D. L. Brakensiek, and K. E. Saxton: Estimation of Soil Water Properties. Trans. American Soc. Agric. Eng., vol. 25, no. 5, 1982, pp. 1320, 1328.
- 8-123. Rawls, W. J., D. L. Brakensiek, and B. Soni: Agricultural Management Effects on Soil Water Processes: Part I, Soil Water Retention and Green-Ampt Infiltration Parameters. Trans. American Soc. Agric. Eng., 1983.
- 8-124. Rawls, W. J., T. J. Jackson, and J. F. Zuzel: Comparison of Areal Snow Sampling Procedures. Proc. American Soc. Civil Eng. Watershed Management Symposium, 1980.
- 8-125. Rawls, W. J., T. J. Jackson, and J. F. Zuzel: Comparison of Areal Snow Storage Sampling Procedures for Rangeland Watersheds. Nordic Hydrology, Dec. 1979.
- 8-126. Rawls, W. J., A. Shalaby, and R. H. McCurn: Comparison of Methods of Determining Urban Runoff Curve Numbers. Paper 80-2565, American Soc. Agric. Eng., 1980.
- 8-127. Ritchie, J. C.: Agricultural Research Service Research Highlights in Remote Sensing for Calendar Year 1981. Review of USDA/NASA/NOAA joint publication, EW-R2-04345, JSC-18268, 1982.
- 8-128. Ritchie, J. C.: Remote Sensing and Erosion Research. Proc. Natural Resources Modeling Symposium, Nov. 1983 (submitted for publication).
- 8-129. Ritchie, J. C., F. R. Schiebe, and C. M. Cooper: Remote Sensing of Suspended Sediments in Surface Water. Abstract of paper for the Forty-Fifth Annual Meeting, American Society of Limnology and Oceanography, p. 55.
- 8-130. Ritchie, J. C., F. R. Schiebe, and C. M. Cooper: Spectral Measurements of Surface Suspended Matter in an Oxbow Lake in the Lower Mississippi Valley. J. Freshwater Ecology, vol. 2, 1983, pp. 175-181.
- 8-131. Ritchie, J. C., F. R. Schiebe, and J. A. Harrington, Jr.: Summary of Remote Sensing Studies on Lake Chicot. Arkansas Lake Symposium (Lake Chicot), Oct. 1983.
- 8-135. Schiebe, F. R.: Remote Sensing of Water Quality. University of Minn., Apr. 22, 1981.
- 8-136. Schiebe, F. R.: Solar Radiation Balance in Sediment-Laden Waters. U.S. Geological Survey, National Space Technology Laboratory, Oct. 1979.
- 8-134. Schiebe, F. R., J. O. Farrell, and J. R. McHenry: Water Quality Improvement of Lake Chicot, Arkansas. Proc. Symposium Surface Water Impoundment, 1980.

- 8-135. Schiebe, F. R., J. C. Ritchie, and G. O. Boatwright: A First Evaluation of Landsat TM Data to Monitor Suspended Sediment in Lakes. Proc. Landsat-4 Early Results Symposium, Goddard Space Flight Center (Greenbelt, Md.), 1983.
- 8-136. Schiebe, F. R., J. C. Ritchie, and G. O. Boatwright: A Preliminary Evaluation of Thematic Mapper Data to Measure Suspended Sediments in Lake Chicot, Arkansas. Landsat-4 Scientific Characterization Early Results Symposium, 1983, p. 150.
- 8-137. Shafer, B. A., E. B. Jones, and D. M. Frick: Snowmelt-Runoff Modeling in Simulation and Forecasting Modes With the Martinec-Rango Model. NASA Contractor Rep. 170452 (Greenbelt, Md.), 1982.
- 8-138. Shiue, J. C., R. Shin, B. Hartline, J. A. Kong, and A. T. C. Chang: Microwave Radiometric Observations of Snow and Ice in Northeastern U.S. Snow Symposium II, CRREL (Hanover, N. H.), Aug. 1982.
- 8-139. Stefan, H., F. R. Schiebe, and S. Dhamotharan: Suspended Sediment-Temperature Interaction in a Shallow Lake. (Edited by American Soc. Civil Eng. J. editor; being revised by authors.)
- 8-140. Wight, J. R., ed.: SPUR - Simulation of Production and Utilization of Rangelands: A Rangeland Model for Management and Research. USDA misc. publ. no. 1431, Feb. 1983.
- 8-141. Wight, J. R., and R. J. Hanks: A Water-Balance, Climate Model for Range Herbage Production. J. Range Management (accepted for publication).
- 8-142. Wight, J. R., and E. L. Neff: Soil-Vegetation-Hydrology Studies, Vol. II. A User Manual for ERHYM: The Ekalaka Rangeland and Yield Model. USDA-ARS, Agric. Res. Results, ARR-W-29, Jan. 1983.
- 8-143. Woolhiser, D. A., and D. L. Brakensiek: Hydrological Systems Synthesis. American Soc. Agric. Eng. Monography on Hydrologic Modeling of Small Watersheds, Mar. 1981.
- 8-144. Zuzel, J. F.: Conditional Flow Simulation Model. Water Resources Res. (accepted for publication).